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Presenting Musical Concepts Through Video Game Technology

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Presenting Musical Concepts Through Video Game Technology

Interactive Qualifying Project Report: E-term 2017

Submitted by:

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Department of Humanities & Arts
WORCESTER POLYTECHNIC INSTITUTE

A report submitted in partial fulfillment
of the requirements for the degree of
BACHELOR OF SCIENCE

Advisor:
V.J. Manzo

August 23, 2017

This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review. For more information about the projects program at WPI, see <http://www.wpi.edu/Academics/Projects>.

ABSTRACT

Learning music can be challenging, and musical instruments are often expensive. Research suggests that by leveraging technology and videogames, it may be possible to provide an innovative alternative to traditional music learning so that people can learn basic music concepts in an immersive, engaging and cost-effective way. Through this IQP, our team explored the potential of mobile applications to teach relative pitch informally to a wide audience of both musicians and nonmusicians. Our background research resulted in a prototype intended to serve as a self-guided music learning application to learn relative pitch informally. After developing the prototype, we conducted four interviews with professional music educators to gather feedback on our design and the viability of an application as an informal learning tool. We then refined the prototype according to the feedback and surveyed a second group of participants with varying music skills in order to gather more general feedback. The results suggest that although our game was successful in captivating the user's attention, it failed to hold their attention in the long term as the difficulty curve was too steep.

ACKNOWLEDGEMENTS

We would like to thank Professor V.J. Manzo for advising and guiding us throughout this entire project. He offered his insight freely and in turn listened to our ideas with an open mind. His constant support allowed us to focus to make the best possible project within the constraints.

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AUTHORSHIP

All parts of the report, including editing, were done in equal amounts among Bhon Bunnag, Yeggi Lee, Alex Taglieri, and Yil Verdeja.

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1 INTRODUCTION

Learning music, like anything else, takes time and dedication. Unfortunately, many of the people who begin studying a musical instrument quit in the early developmental stages. Currently, many schools are finding that their budgets for music education are shrinking. The problem that this project aims to address is that current methods of teaching music are inefficient, both in terms of their cost and in how much enjoyment these teaching methods provide their students per unit of time that students invest.

Over the time period in which mobile games have been under development, game designers have made serious progress towards making games that are enjoyable. There is an art form to designing games in such a way that players are enticed to spend more and more of their time inside the app.

The particular goal that app designers have been optimizing - that is, trying to make people spend as much free time as possible using their product - happens to translate very nicely to the way in which humans learn. We learn best when we are immersed in an environment. And if we spend five hours on a given task, we will learn many things about what we are doing, even if the expected learning outcomes are unclear. Anybody who has spent way too many hours playing Tetris and then daydreamed about falling blocks¹ understands the power that video games can have over an individual. The fact that it has such a strong influence on people can be used for educational purposes.

The innovative feature of *Name of Game* is that it is entertaining and addictive. Our research suggests that there is a specific niche in education that can be filled with a game that entices users to spend hours at a time practicing skills that would otherwise be considered the “boring” part of practice. The goal is to create a game that is tuned to cause the player to release endorphins in response to carefully planned activities. The logic is that if app designers can convince people to spend lots of time hitting a single button repeatedly - arguably the most boring thing one could do on a mobile device - then we can surely exploit the same tendency of humans to seek reward to teach skills important for making and understanding music.

¹ The phenomenon is so common amongst Tetris players that it has been given the designation “Skyline Tetris”

2 BACKGROUND

In this section, we will begin by exploring the decline in the number of students participating in formal music education efforts in America despite the benefits that music provides. Later on, we looked into how formal and informal education differ. Also, various reviews of several apps were included to show how technology has become prevalent in the education scene. We will ultimately posit that educational video games that utilize informal learning approaches can be an effective way of imparting musicianship skills both within and outside of the traditional music classroom.

2.1 Music Background

2.1.1 The Importance of Music

Music plays an important role in the development of human cognitive skills[1]. It leads to substantial changes in the brain's structural plasticity [2] and enhances the ability to recognize speech [3] as well as verbal memory. A study has shown that people who have been trained musically since childhood have an advantage in processing speech from noise. As a result, music is shown to accelerate language acquisition [4] and improve learning in many other subjects in general [5].

In addition, music plays a key role in human socialization. A study has shown that musically trained students were more likely to socially engage with parents and teachers[6]. Similarly, multiple research studies have shown that music competency led to higher motivation and success in school[7]. Music is an activity that balances both the need for individual practice and collective synchronization, which develops an empathetic quality among musicians.

2.1.2 Current State of Music

The number of students who formally participate in their school's music education programs has been in decline [8]. A study in California public schools show that student participation in music has suffered an overwhelming decline by 46.5% from 1999 to 2004, the largest drop in any subject area. The number of music teachers has also dropped by 26.7% [9]. Figure 1 shows further evidence to this decline.

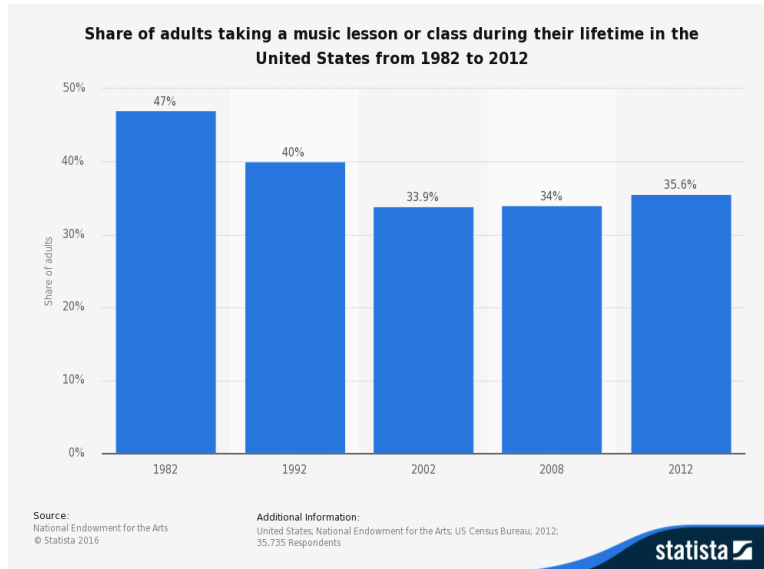


Figure 1: Population of adults who have taken music lessons at some point their life

However, the influence of music is becoming more dominant in our daily lives. As shown in Figure 2, the newer generation is more actively playing music than the previous. 56% of the 18 to 20 year olds are classified as currently playing music, which puts them the highest among the categories..

Fig 15. Instrumental playing: playing by age Adult learners

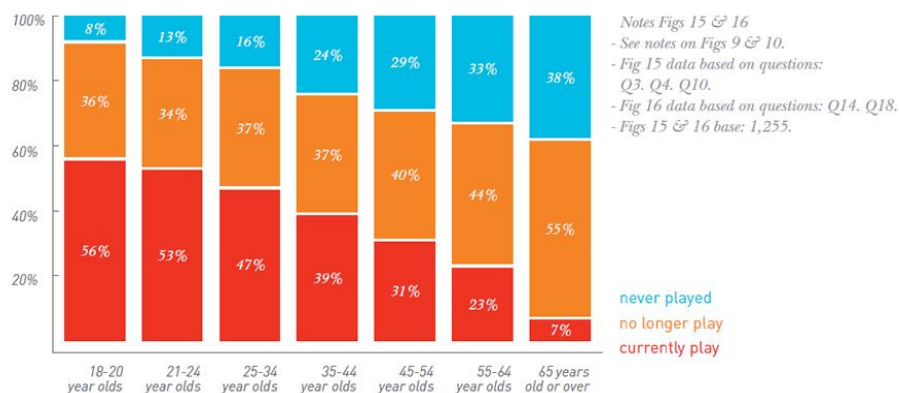


Figure 2: Population of adults who are currently playing an instrument, have played an instrument, and have never played an instrument

In other words, musicianship is moving away from formal music theory in the classrooms. Perhaps this is modulated by new advancements in technology, especially the internet. Music is shared at a magnitude never seen before; Youtube is home to many online tutorials and lessons

for various aspects of music. Noticeably, this method of learning is more fluid and less formal. This attracts more people to pick up music as a hobby. Furthermore, these media sharing platforms offer a means for amateur musicians to express their musical talents and mediate their growth in music[41].

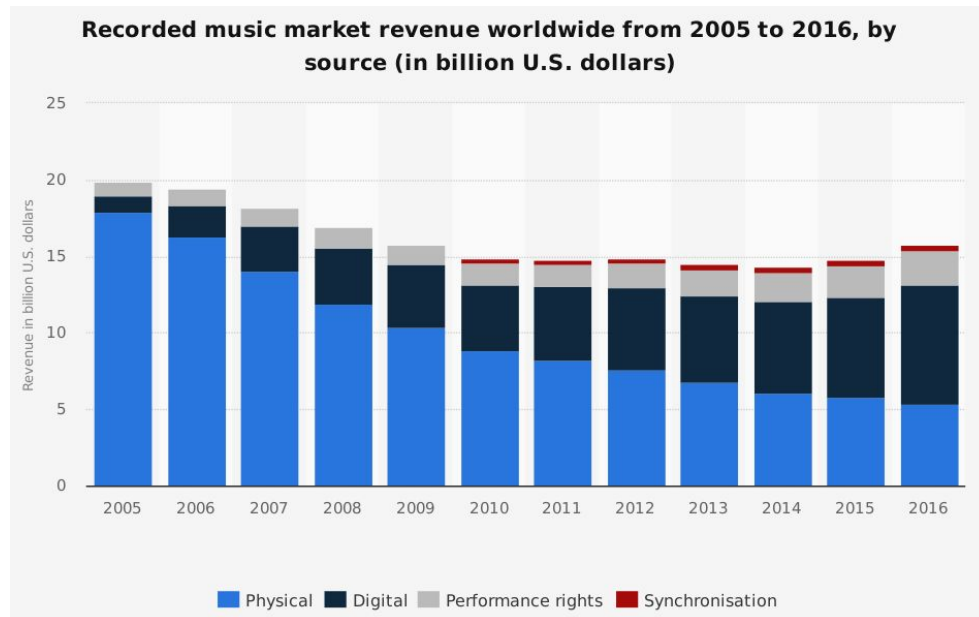


Figure 3: Graph of digital music revenue worldwide from 2005-2016

2.1.3 Formal vs. Informal Teaching

Formal Overview

Formal music learning, as opposed to informal, is implemented through a curriculum developed by sanctioned educational institutions. As a result, it is credential based and explicitly goal-oriented with the purpose of meeting the National Standards of Music Education (MENC).

[10] These standards are set by the National Association for Music Education (NAfME) and include:

- Singing, alone and with others, a varied repertoire of music
- Performing on instruments, alone and with others, a varied repertoire of music.
- Improvising melodies, variations, and accompaniments.
- Composing and arranging music within specified guidelines
- Reading and notating music
- Listening to, analyzing, and describing music
- Evaluating music and music performances
- Understanding relationships between music, the other arts, and disciplines outside the arts
- Understanding music in relation to history and culture. [10]

Schools usually implement formal music learning at an early age and students can choose to continue on to higher levels. The curriculum, which favors classical music, is highly hierarchic with elementary skills and theories setting the basis for further and more complex knowledge [11]. Tasks are often slowly incrementing and successive which leads to a more thorough education, allowing students to adapt their skills to suit different situations. As such, mastering the theory is just as important as proficiency in the chosen instrument.

A set curriculum allows students to know what to anticipate and what they will be assessed on. Therefore, students are expected to hold a command of a set of skills and certain facts which they will be tested on throughout their education. Assessment is more focused on the ending result rather than the process and prepares students for entering a potential higher education such as universities and later on into a vocation. [12]

Informal Overview

With the rise of YouTube, apps, and the Internet, learning music informally has become commonplace. As shown above, formal music training has dropped significantly throughout the years due to a lack of motivation, resources, and time.

According to Peter Mak, a member of the lectorate Lifelong Learning in Music, the following features are key to informal learning [12]:

- Organic
- Contextual
- Experience-based
- Learning is not the main aim
- Individual learners as opposed to teachers
- Collaborative

As opposed to formal training, the end purpose is not clearly defined or assessed in informal training. As it is all based on self-motivation, the learner chooses what they want to learn and sets their own goals. Informal learning is more experience-dependent and often requires a more hands-on learning such as playing a game. More and more applications such as DragonBox Algebra² and Word Raider³ are being released in order to help people learn new skills. Much like these games, we designed an application that was meant to teach a skill in a fun and innovative way.

² Link to DragonBox Algebra: <http://dragonbox.com/>

³ Link to Word Raider: <http://www.word-raider.com/>

2.2.1 Technology Influencing Education

The great technological shift of the past twenty or so years has led to some unexpected innovations in the field of education. Sal Khan, the innovator behind the website Khanacademy.org, has made it his mission “to provide a free world-class education to anyone, anywhere” [43]. He says it was once believed that the best way to learn was by sitting a group of twenty to forty students in front of a teacher who would lecture them for 45 minutes to 90 minutes. However, he stated that this method of teaching is wrong because it creates “swiss cheese gaps” in students’ knowledge [44]. He spends his time creating short, focused educational videos on YouTube and KhanAcademy that are around 10 minutes in length. Now, students can go on the Internet and learn a specific skill on their own time. With videos in this shorter format, it’s possible to actually engage the student for the whole video. Khan says that humans are simply bad at focusing on a single topic for an hour at a time [43].

There is a story often told [13] about the industrial revolution of the early 1900’s that has parallels to the information revolution of today. It is said that when electric motors were first introduced to the world, factories did not adopt them immediately. Factories up until that point had been arranged around a central shaft [14]. The first factories to adopt electric motors instead of the steam power that had been utilized previously did so naïvely: factory owners simply replaced the old steam-powered machinery with electrical machines. The real benefit of electric power, though, is that factories don’t need to be arranged with all the workstations directly adjacent to a central shaft. Machinery can be grouped in ways that make sense rather than being restricted by the steam shaft. It wasn’t until factory owners realized that there was no longer a need for wasted space that electric factories became so much more efficient.

The story of technology in education can be compared to the story of electric power in factories. The current state of education is not meaningfully different from how education looked before the introduction of the Internet. To Sal Khan’s dismay, children still go to school for six to eight hours a day where they sit in a classroom while a teacher teaches [44]. We as a civilization are similar to factory owners who recently adopted electric machinery in that we will not realize the benefit of technology until we fundamentally alter how our classrooms are arranged. It no longer makes sense to have classrooms arranged around the schoolroom equivalent of a steam shaft if we can instead allow students to spread out like electric machinery and learn independently. Sal Khan’s method of personalized learning [46] is the path towards a better classroom.

2.2.2 Music Related Applications

There exist many music-related application and pieces of software. Some are more focused on learning and training music, while others use music merely as a means for entertainment. In this section, we explore different pieces of software across the education-entertainment spectrum.

Entertainment

Guitar Hero

Guitar Hero is a music rhythm game, composed mainly of rock songs from the late 20th century and early 21st century. In the game, notes of different colors and positions fall down along vertical guitar fretboard. The player then must hit the correct corresponding note within a given time frame. The player utilizes a guitar-shaped controller; in order to play a note, the player needs to hold down the corresponding note with one hand, and strum with another, similar to a real guitar.

Guitar Hero received high praise from IGN and earned over \$45 million dollars with 1.5 million copies sold upon release of the first game [42]. According to Kiri Miller, this success lies in the game's ability to simulate the 'Rock Star experience' to its user [15]. Even people who know little about music can experience the thrill of being on stage, as the virtual crowd cheers you on. Furthermore, most of the song selections are of the classic rock genre, featuring many iconic rock songs which appeal to a wide audience.



Figure 4: The UI of a player performing Lynyrd Skynyrd's Free Bird with Star Power, a special mode that gives the player a score boost.

osu!

osu!⁴ is a free-to-win⁵ rhythm video game consisting of game elements (circles, spinner, sliders) that appear on the UI, in which the players must click in time with the rhythm of the music to score points [16].

osu! boasts 10.5 million users, with over 10,000 active users daily [16]. The focus of the game lies in its community rather than the actual gameplay. Osu! has a well designed multiplayer and leaderboard system, which inspires a lot of competition and interaction among players. This is further evident to the nature of the game itself. The different stages of osu!, which are called beatmaps, are all created by players. The direction of game development is also strongly influenced by the community as a whole. This ‘giveth and taketh’ structure creates a feedback-loop that keeps the game developing for its players, by its players.



Figure 5: The current #1 player, Cookiezi, performing Freedom Dive

Piano Tiles

Piano Tiles is a single-player phone-application for the Android and the iOS [17]. The game concept is very similar to Guitar Hero as the player must hit the correct notes as they fall down from the screen. However, they differ in the user-interface: whereas Piano Tiles uses piano keys,

⁴ Literally ‘press!’ in Japanese

⁵ Free-to-win games refer to video games that do not require users to pay money for extra features in order to gain a significant advantage in the game.

Guitar hero uses the fretboard. Most of the songs featured are classical music, and the notes played are sound-mapped.



Figure 6: Gameplay of Piano Tiles

Piano Tiles uses the ‘Freemium model’, where the main game is free of charge, though extra features (for aesthetics or an enhanced experience) may be bought in-game if the player so chooses to. This model has attracted both payers and non-payers, and earned the app over 300,000 downloads and the #1 spot in the free game category in over 40 countries [45].

Educational

Perfect Ear - Ear Trainer

The Perfect Ear – Ear Trainer [18] is an educational app that helps people develop better aural skills and a sense of rhythm. Its objective is to train beginners and professionals to become better musicians by improving their skills in improvisation, relative pitch, recognition of musical components, and other aspects of music that are crucial in improving one’s level of musicianship. As stated in their app description, Perfect Ear “provides [people] with high quality, unique ear training, rhythm training and solfège capabilities.” Not only are the mechanics of the application splendid, but the user interface has a simple and easy-to-use design. It has been rated 4.7 stars out of 5 from to 40,000 users by July 2017, making it one of the best ear training apps in Google Play.



Figure 7: Logo of Perfect Ear - Ear Trainer

2.3 Game Background

After investigating various music games, we decided to design a software application in order to make a viable self-directed music learning app. Further on, we will outline the preliminary design choices of the game based on previous music applications, relative pitch training, and skill progression games. Ultimately, we will design an application that teaches relative pitch to a wide audience of phone users, using an ‘incremental game’ design to keep users engaged.

2.3.1 Target Audience

In principle, the target audience of the software is the entire population of people with access to smartphones. However, the focus audience is young adults between the ages of 18-40 in the USA. Figure 8 shows that over 75% of the American adult population owns a smartphone device. In fact, extrapolating the data shows that the number of smartphone users is expected to increase to over 90% within a decade. Though figure 9 shows that there are just as many desktop/laptop computer users, the desktop/laptop number of users is expected to stagnate in the next few years.

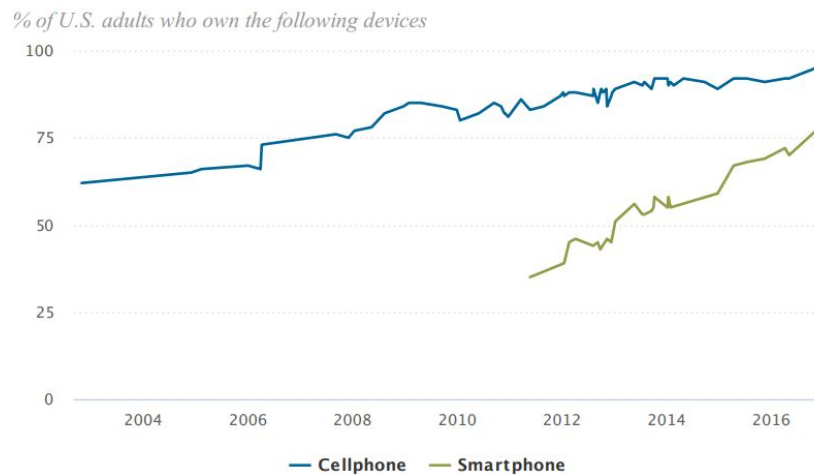


Figure 8: Percentage of American adults who own cell phones vs smartphones

There are several variables that influence smart phone ownership. Figure 10 shows that the main users of smartphones are young adults. 98% of the people aged between 18-24 are phone users, and 97% of people aged between 25-34 are phone users. This justifies our choice of audience on which to focus.

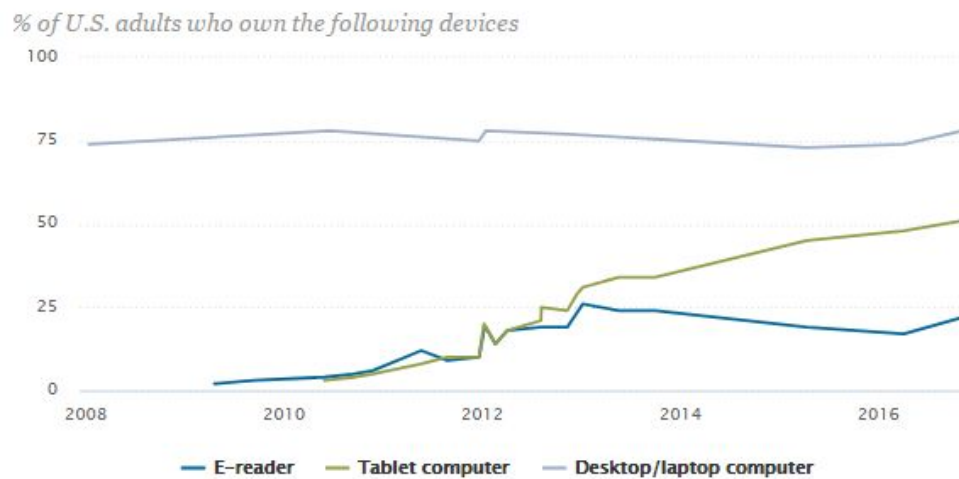


Figure 9: Percentage of adults who own e-readers vs tablets vs desktops/laptops

According to Pew Research Center, only 64% of people earning less than \$30,000 annually have smart phones, while 93% of people earning more than \$90,000 annually have smartphones. However, research published in the journal *Pediatrics* noted an ‘almost universal exposure’ to

mobile devices[19]. Although socioeconomic variables play a role in phone ownership and usage, smartphone application still remains an effective way to reach out to a wide population.

US Smartphone User Penetration, by Age, 2014-2020							
<i>% of mobile phone users in each group</i>							
	2014	2015	2016	2017	2018	2019	2020
0-11	28.7%	35.3%	41.0%	45.0%	47.1%	48.9%	49.7%
12-17	71.0%	78.5%	84.0%	89.0%	91.0%	92.0%	92.9%
18-24	85.2%	90.1%	94.9%	98.0%	98.4%	99.0%	99.4%
25-34	84.0%	90.2%	95.2%	97.0%	97.1%	97.2%	97.3%
35-44	81.6%	87.7%	92.0%	94.0%	94.8%	96.1%	97.0%
45-54	66.9%	75.8%	82.8%	88.3%	92.8%	95.9%	97.9%
55-64	59.1%	67.6%	75.7%	80.9%	85.5%	89.5%	93.0%
65+	36.6%	40.7%	44.4%	49.6%	52.8%	55.7%	55.4%
Total	67.6%	73.8%	79.0%	82.7%	84.8%	86.5%	87.3%
<i>Note: individuals who own at least one smartphone and use the smartphone(s) at least once per month</i>							
<i>Source: eMarketer, Feb 2016</i>							
204491	www.eMarketer.com						

Figure 10: Percentages of mobile phone users in the USA

2.3.2 Game Platform

Many schools enable students to have access to computing devices. Districts across the United States spend money to acquire educational technology for students between kindergarten and 12th grade. For example, in 2014, these American schools spent almost \$10 billion on educational technology according to Joseph Morris, about a third of which is dedicated to computer hardware [20].

While many of these programs originally purchased are Apple products, a trend is emerging among schools to transition to less expensive hardware. It is commonly understood that Apple's customers are the ones who are willing to pay the most money for technology [21]. Apple has consistently taken 15% of the market distribution for Smartphone ownership by number of devices over the time since the iPhone was released. The other 85% of devices are Android devices [21]. Schools began realizing that they could accomplish more net teaching per dollar spent by purchasing Android devices rather than iPhones and iPads: school districts in Texas, North Carolina, and Los Angeles all changed their policies to switch Apple devices for other, cheaper devices [22,23,24], such as Androids and Chromebooks.

Any program that is meant to be used in American schools should take the market conditions into account and be compatible with Android and Windows products with a higher priority than Apple products.

In addition to devices that schools purchase with the intent to give to students for home use, many schools have computer labs. These labs are almost always stocked with computers running Windows.

The app is designed to be suitable for everyone, regardless of age, socioeconomic status, and level of musicianship. Whether the person using the app is accessing it through a school or through their own personal device, it will be easiest to transfer the app from one device to another if it has been written in Java. Apps written in Java can run on both Windows and Macintosh computers (and all other unix-based systems for those who like to experiment with their operating systems). Java is also the main language used in Android app development, so a game written in Java can run on anything except iPhones. As iPhone owners are the one demographic that needs to be targeted the least for this game, Java provides an ideal audience.

2.3.3 Relative Pitch and Ear Training

To be able to design a self-directed music learning application, we further looked into the theory of relative pitch, including those of sight reading and ear training. Sight reading is the ability to perform a piece of music (in music notation) without previous preparation or study [25] while ear training is to be able to recognize and identify music concepts solely by hearing. Our music study will focus more on creating a game that is engaging and teaches music theory through ear training.

With ear training, an essential skill to acquire is relative pitch. Relative pitch (RP) is the ability to identify or recreate a given musical note and to be able to identify the interval⁶ between that note and a reference note. On the other hand, absolute pitch (AP), also known as perfect pitch, is the ability to identify or recreate a given musical note without the benefit of a reference note. Someone who has AP can accurately produce any heard tone without thinking about it. Based on research, we decided to focus on teaching RP, as AP is not required in order to become a good musician. Our application was designed to help people understand how to determine the relationship of notes being played.

The traditional approach for people to obtain a much greater aural perception were through classes, where students are “systematically trained to identify pitches and rhythms and, by practice and guidance, to learn to write them in musical notation.” [26] But the Oxford Companion to Music states that research has shown that this traditional approach isn’t appropriate in meeting students professional needs, since many characteristics of music tend to be overlooked. This method drills sounds in student’s minds with enough repetition, and it can get relatively boring.

⁶ An interval is the difference between two pitches

A modern approach in training one's ears are through applications in technology that not only simplify the process, but also gives more accessibility on what can be taught. EarMaster⁷ is an advanced ear training software that consists in the study of pitches, intervals, and chords. Another heavily used application is Perfect Ear – Ear Trainer, which teaches you how to distinguish intervals, scales, chord, and rhythm with training exercises. Our aim is to create an application that challenges the teaching methods that these apps use by creating a game that indirectly trains people's ears.

2.3.4 Skill Progression

The difficulty of a game is a crucial, underlying factor to the user's engagement. Make the game too challenging, and users might quit out of frustration. On the other hand, if it is too easy, they might get bored. However, these roadblocks can be easily avoided if students are challenged in an appropriate level of difficulty [28].

Since our target audience includes non-musicians, the game will be self-paced, avoiding a rigid leveling structure. The beginning of the game will be easy even to non-musician standards. As players get better and obtain more points, they will have the choice of unlocking more notes. This allows the game to become increasingly difficult at the player's own pace.

2.3.5 Player Modes

The main mode of our game was chosen to be single player allowing users to compete and practice against their own scores. Nonetheless, a competitive multiplayer mode to our game is definitely a future goal as it provides much greater enjoyment and satisfaction than single player [29, 30]. Additionally, for educational games, it "is a significant motivator for increased student performance" [31]. If there aren't enough incentives in single player mode, a multiplayer mode should be able to increase performance.

2.3.6 Resemblance to Cookie Clicker

Cookie Clicker⁸ is a Javascript game released by Orteil on August 10, 2013. It's an incremental-type game where a player must click on a large cookie on the left to gain enough cookies to buy buildings⁹ and upgrades. So in essence, every time you click, you gain points. When you buy certain buildings, you automatically gain points over a certain time frame. As you keep buying, more and more updates and buildings are unlocked but at a much greater price.

⁷ Link to Ear Master Application: <https://www.earmaster.com/>

⁸ Link to Cookie Clicker: <http://orteil.dashnet.org/cookieclicker/>

⁹ Buildings are the foundations of Cookie Clicker. Buying buildings and upgrades help a player gradually gain more cookies.

Incremental games have a seemingly endless gameplay where the game can last an indefinite amount of time [32].

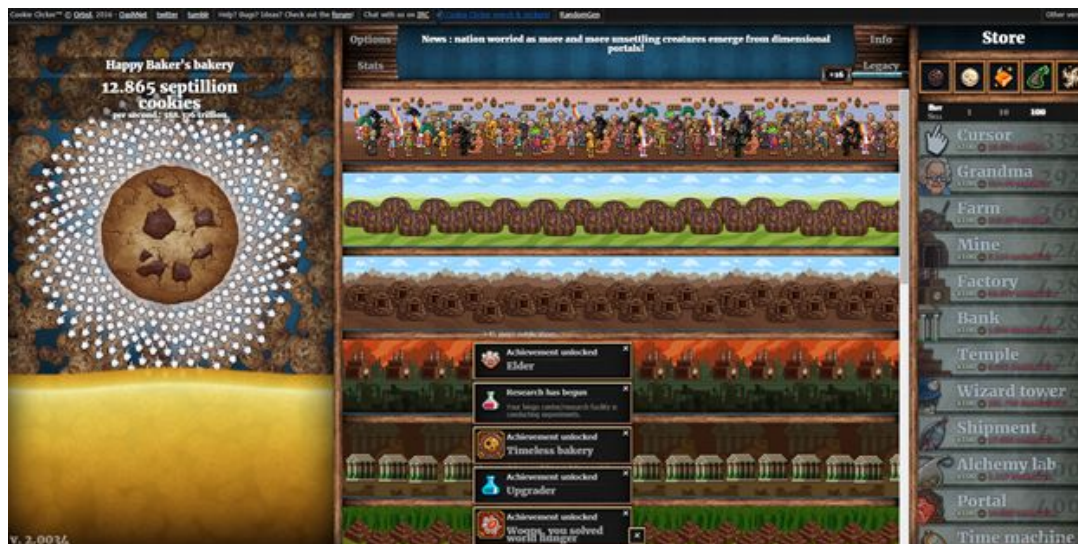


Figure 11: Display of Cookie Clicker

Two reasons as to why incremental games are very addicting can be explained by the “Skinner Box” experiments, and loss aversion. The Skinner Box [33] is a psychology reference for the studies done on behavioral conditioning of animal subjects invented by a US Psychologist and Behaviorist, B.F. Skinner. Each subject was presented with a button that once pressed, would provide them food. The study concluded that once learning of the rewarding mechanism, the animals would repeat the food-producing action, no matter how much they were given. In the case for incremental games, they are perceived as incredibly addicting because when a player performs an action such as clicking or waiting, they are rewarded. On the other hand, loss aversion is the “observation that a loss generally has a greater subjective effect than an equivalent gain.” Studies have suggested that psychologically, losses are twice as powerful as gains [34]. This further illustrates why incremental games are addicting, because you’re not losing anything. Even doing nothing rewards you! [35]

But what is an educational game if it doesn’t teach you anything? Our music game will use an incremental scoring system, and the ability to buy and unlock specific keys as rewards. Instead of mindless and automated clicking, the user will be required to train their ear in order to increment their score. The loss aversion will be taken into consideration: the game will most likely have a score reduction mechanism for any misplayed notes, but a much greater score increment for any correctly played notes.

3 METHODOLOGY

This section consists of three parts: creating an idea based on the background research, designing the game itself, and interviewing and surveying people in the range of our target audience to further improve the prototype.

The idea was to create a game that would be both educational and entertaining, and that could help people identify intervals through ear training. This would greatly benefit the player with their relative pitch skills. Although the initial idea was to create a game with level progression, based on our research, we ultimately decided to resemble our game closely to incremental games such as Cookie Clicker where people self-progress by buying certain items on their own. The toughest part was designing the idea into an actual game. The development process had many aspects to it that included working on the user interface, audio, and programming design.

Throughout the design process, four music and music technology teachers were asked to participate in a focus group in which they gave their expert opinion on how to further develop our application and if our game would be feasible as a teaching instrument. After building a final prototype, we additionally prepared a survey and sent it out to multiple people who fit within our target audience. We wanted to see whether our game was both entertaining and educational when recognizing intervals and asked questions accordingly.

3.1 Introduction

As mentioned previously, the target audience is young adults between the ages of 18 and 40. Since over 75% of U.S. adults own a smartphone, we chose this target audience to allow for a wide and diverse population. Further on, we interviewed several music and music technology experts to gain further insight on whether our game could be a viable self-directed music learning app that would work for a diverse population. We then had various individuals test our game to provide a more rounded view of our game.

3.2 Hypothesis

Many popular games today are able to hold the user's attention by having a good balance between challenges and rewards. Most of these games, however, do not have the driving directive of trying to teach the user something valuable. Based on our background research, we found that the mechanism of incremental games, which encourage addictive behavior, could be useful for people to informally explore aspects of relative pitch.

3.3 Game Design

3.3.1 Overview

The objective of the game is to help both musicians and nonmusicians improve at recognizing intervals through ear training. In essence, they would further develop their relative pitch skills. The main mechanics of the game are to play what you hear and to progress at your own pace. The game consists of a piano that includes 17 keys: 10 white keys and 7 black keys. Each player starts off with three unlocked keys (C, D, E) on the piano. The game generates a note, and to gain points, the player must recreate that note by pressing any of the unlocked keys. The accumulation of points can help the player unlock more piano keys, or replay the note if the sound was forgotten.

3.3.2 Platform and Development Environment

The primary development tool we used for designing *Name of Game* is the Eclipse environment. We chose the Java programming language because as explained in 2.3.2, it allows us to design Windows applications which can later be transposed into an Android application with ease. In code sharing and management, we used Git via github.com. A private repository was created, which was synced with Eclipse using the EGit plug-in software.

3.3.3 Ear Training

The primary objective of *Name of Game* is to help players recognize intervals through ear training. As explained in section 2.3.3 *Relative Pitch and Ear Training*, the purpose of ear training is to improve a listener's conscious and intellectual grasp of what the ear can hear. It benefits the learner as it gives them the ability to recognize and identify music concepts solely by hearing. [26]

The start of the game will begin with an arpeggio in C as it helps the player comprehend the notes relative to the other keys in the piano and establishes a tonal center. Since our target audience includes non-musicians, it's best to introduce the game by familiarizing the players on how the notes function on a piano.

The 'playing what you hear' mechanism is, in principle, how *Name of Game* trains a user's ears. A player's streak (and score) is an evaluation of how well they can recognize the notes that are unlocked. As users get better, buying more notes not only helps them expand their relative pitch skills, but as motivation, it rewards them with more points for every correct note. Although the note prices increase, by the time a user's score is more than or equal to the price of unlocking a certain key, they should be ready to progress to a wider range of notes.

Although the actual game only has the ability to unlock notes on a piano, the full game design includes the ability to unlock major and minor chords, and notes in sequence (as seen on Figure T). A player needs to unlock the whole piano in order to unlock the rest of the modes. These modes help increase the player's ability to distinguish notes at a higher capacity. The chord and sequence mode trains the player to recognize multiple notes simultaneously and in progression respectively.

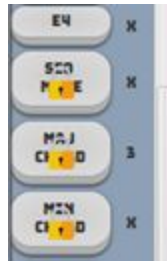


Figure 12. Store Extended – Unlocking Key E4, Sequence Mode, Major Chords and Minor Chords

3.3.4 Saving Progress

Having a saving mechanism plays a crucial part in any sort of game. Because our application is both educational and point-based, we decided to add a save button. This would prevent users from having to start from the beginning - a common pitfall in any educational game. Players who have already learned the previous material should not be forced to go through it again as it may be under-challenging or discouraging. Additionally, this would allow players to play at their leisure and not have to finish the entire game in a single session.

3.3.5 Game Mechanics

In the beginning, the game will ask the player to press any piano key in order to start. When the note is pressed, the corresponding note will play, and that will serve as the reference note. Then, the program will generate a random note from the unlocked notes. The player must press the corresponding note, in which if the player succeeds the player will earn points, and their streak will increase by 1. If the player presses an incorrect note, the streak resets to zero and 10% of the score is subtracted from the total. This establishes a 'pain point' when a player loses a high streak and makes the game considerably difficult when trying to accumulate more points [36].

Once the player obtains a high enough score, the player can choose to unlock piano notes in the store. Buying notes will increase the multiplier, however it will also increase the price of other notes by a multiplier of 1.6, and increase difficulty of the game.

The score for getting a note correct is calculated as a function of the streak and the multiplier. For every 10 streak, the base score is increased by 1. The entire base score is then multiplied by the multiplier, which gives the total.

3.4 Game Development

3.4.1 User Interface (UI)

Piano Design

The piano was chosen as our main design for a few important reasons. First of all, the piano is a widely recognizable instrument that is versatile enough to be played within any music genre such as classical, jazz, blues, and more.

Secondly, based on our background research, our target audience is young adults between the ages of 18 to 40. As such, we decided that childish graphics were off the table and it would be best to have something that could be easily related to.

Finally, nowadays, both the guitar and piano are both very popular instruments to play. We deliberated on which to use, but ultimately the latter was picked. Our game is not about teaching an instrument, but rather more inclined to teach the user how to listen and recognize intervals to improve relative pitch. With a guitar, specific notes might need the use of multiple fingers, making the game unnecessarily complicated. The design was purposely made simple so that even non-musicians could play without having any prior experience.

Interface Design History

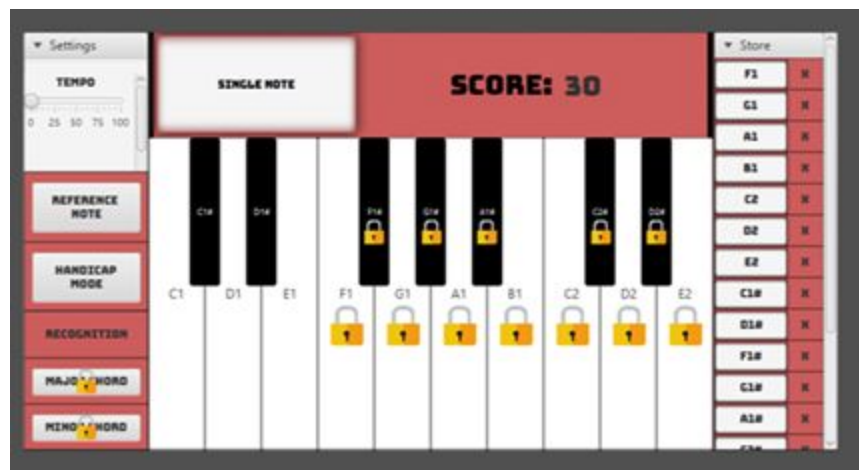
For the interface of *Name of Game*, two different scenes were used: one for the main menu and the other for the single player mode.

The first prototype had a game level design in which players progress through different stages with a specified curriculum. Figure 12 demonstrates our starting design which was rudimentary with only a piano, a level progression bar, and an assorted group of buttons. Once the player started leveling up, the game would become much harder as more keys became unlocked. However, we decided that the game idea resembled an application, rather than a game.



Figure 13: Initial Interface of Previous Idea

Later on, we decided to go towards the incremental game route, which significantly impacted the user interface. The figure below represents the first prototype of the single player UI. Everything but the piano was stripped off the previous UI.



recognition, and a tempo changer. Ultimately, we decided they were unnecessary and scrapped that part of the project.

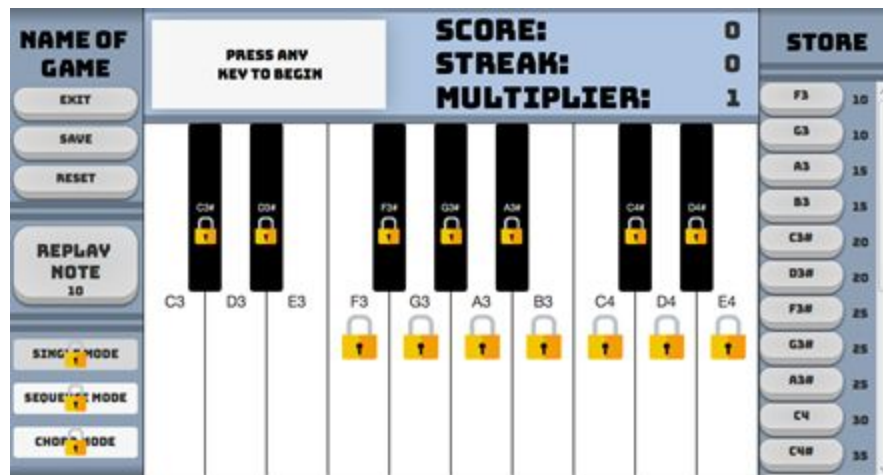


Figure 15. Second Prototype of the Single Player UI

The second prototype of the UI, demonstrated in Figure 15, allows the player to exit, save or reset the game. Instead of playing a reference note, the player can replay the note at a certain cost. The biggest change was the colour of the background which transitioned from red to blue. Research showed that blue is the best colour to acquire a user's attention. [37] Additionally, aside from the score, the streak and the multiplier were made visible to allow users to understand how their scores are calculated. A note box on the top left was also included to help users understand what is happening in the game as they take part of it.



Figure 16: Previous Main Menu UI



Figure 17: Current Main Menu UI

Between the two figures above, Figure 17 is the more appealing one due to its background colour, spacing between the buttons and title, and the piano keys on the side. The background colour changed to resemble the interface colour in the main game UI. Furthermore, piano keys were added to the sides because not only does it fit the theme of our game, but it also increases interactions between the player and the UI.

3.4.2 Tutorial

A tutorial is a method of transferring knowledge used in the learning process. In games, tutorials serve as a way to help guide the players in understanding how to play the game through examples and by supplying sufficient information to complete a task. For our game, an interactive in-game [38] tutorial would be ideal because it restricts the player from playing the full game until they have demonstrated their ability to complete the basic gameplay. A tutorial such as this one, where players are forced to execute certain actions, can make sure that the player is unable to progress until they have mastered specific tasks. This not only increases the retention rate, but it assures that the player understands the main mechanics of the game in order to play at their own pace.

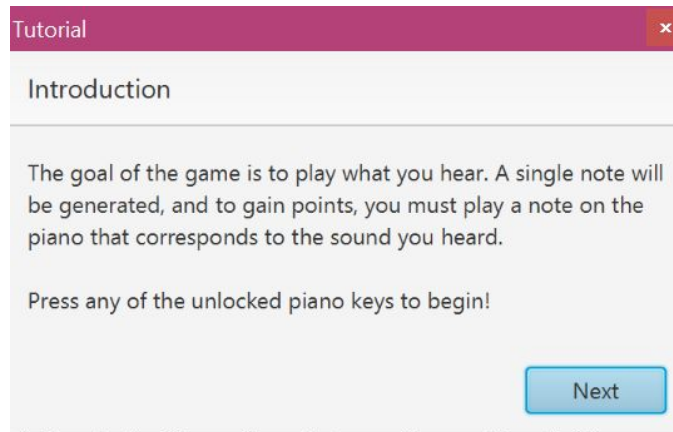


Figure 18: Tutorial box that introduces the game to the user

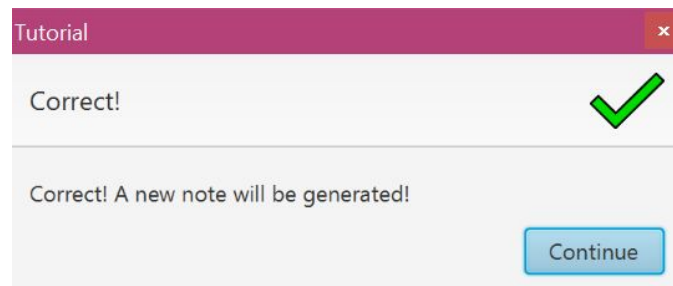


Figure 19: Tutorial box that appears after playing the first correct note

Due to the limited knowledge in creating a game with the chosen development environment, our tutorial consists of pop-up dialog boxes. Each box has minimal text describing what the player has achieved, as well as what they can or should do. In the figures below are two of the tutorial boxes that appear in the game. Figure 18 appears after entering single player mode, and is used to help the understand the goal of the game. Figure 19 appears after users play their first correct note to help familiarize them with the icon that indicates that the input was correct.

This might not be the ideal interactive tutorial, but nonetheless, it should help the player understand the basic mechanics of the game in order to play it properly.

3.4.3 Audio

The audio was generated and recorded with the Piano Simulator in GarageBand¹⁰. The piano was chosen because it is one of the most popular and recognizable instruments. In addition, it suited the game environment we were making for the UI. We made the notes approximately one second long in order to prevent a delay bug in the game.

¹⁰ Link to GarageBand: <https://www.apple.com/mac/garageband/>

Furthermore, we added certain sounds to indicate whether the user played the note correctly or incorrectly. Originally, a correct sound, similar to a coin being flipped, was implemented. However, after discussion with the focus group, this was removed in order to prevent confusing the player. The incorrect sound remained though and is different enough from the piano to alert the player that they chose the wrong note. Furthermore, there's another distinct sound when the player has used all their tries, meaning that a new note will be played.

3.4.4 Programming Design

The foundation of *Name of Game*'s design is based upon the *Model-View-Controller* (MVC) software architectural pattern. In short, in the MVC design, the user directly interacts with the 'View', which is essentially the UI and all of its components. Different inputs on the UI activate different 'Controllers' which manipulate the data, the nature of the software and the elements that are contained in the 'Model'[39].

Using Java, we opted for the Object-Oriented-Programming (OOP) language model [40]. In OOP, program code is grouped according to state and behavior, known as classes. These classes can be instantiated into objects, where abstract data and functionality provided by the class can be defined with concrete values.

Utilizing these two concepts, we organized the code into four separate sections: the model, the view, the controller, and the game launcher. The game launcher is a single instantiated class extending from the built-in Java Application class. It contains the main() function, which sets the UI to the main menu and launches the program.

As described in 3.4.1, we designed two separate UI's for the main menu and the single player mode. We used the JavaFX for the Graphical User Interface (GUI) design. This was achieved by using *Scene Builder* to design the layout, which was stored in the FXML and CSS files.

Similarly, we created two different classes for the controller, one for the main menu and one for the single player mode. The controller was linked with the view through the #onHandle parameter in the FXML file. This is the base of the controller classes, since all interactions with the software is through buttons. When the #onHandle functionality is called, both controller classes will get the identity associated with the button that was clicked, and proceed accordingly.

Finally, we constructed a single model class for the single player mode. The model contained the players statistics including the score, streak, buttons unlocked, etc.

3.5 Prototype Testing

When testing the prototype of the application, we created two different groups: A focus group and a survey group. The focus group consisted of (n=4) music and music technology educators. They tested out our application and had an interview with us in which they provided valuable feedback (Appendix A). We then refined our game based on their feedback before distributing the game along with a survey to our second group.

The survey group consisted of (n=39) people within our target audience. The first part of the survey was to collect demographic data. We wanted to understand who the participants were, as well as their musical experiences. After playing the game, the participants would answer more specific questions in order to help us understand what they thought about the game (Appendix B).

3.5.1 Objectives

For the focus group and the survey group, both qualitative and quantitative data was collected as feedback for our game. We believed that having both types of data would allow for a larger scope as to how the game functioned and how it could improve in the future.

For the focus group, we hoped to:

1. Understand the importance of relative pitch
2. Evaluate the educational value of our application
3. Receive qualitative feedback on our application

On the other hand, the survey group was conducted in order to:

1. Understand how users interacted with the application
2. Determine whether our hypothesis of the game and our users can be justified
3. Receive quantitative and qualitative feedback on our application

3.5.2 Focus Group Procedure

Our group sent emails to music experts and professors to whom we were referred by our advisor, V.J. Manzo. Within the email, the questionnaire for the focus group was included as well as an introduction to the research and a consent form. The respondent read the consent form and his/her signature was obtained in the case that they chose to participate. The interviews were conducted via online conference calls. During the interview, we presented our preliminary design to the respondents in the focus group, and asked a series of questions, which can be found in

Appendix A. The answers were used to identify the educational potential of our software application.

3.5.3 Survey Procedure

The survey was distributed through various means, including word-of-mouth and social media. As an incentive to take the survey, all participants who submitted their email address were added to a \$40 raffle, where a single winner was picked randomly from all the participants. Participants who gave constructive feedback increased their chances of winning the raffle.

4 RESULTS & DISCUSSION

4.1 Focus Group Findings

The focus group gave us valuable insight into another perspective of relative pitch. The notion of relative pitch was more than the ability to identify one note ‘relative’ to another known note. It was also interrelated with understanding intervals in music, and identifying the key in which the notes are in.

The main takeaway from the focus group is the need of a tonal center in order to establish the key, which was missing before we had a descriptive understanding of relative pitch. Initially, we had the player press any key on the piano, which served as the relative note. In order to establish a well defined tonal center, we had the game play a C-Major arpeggio when the game is launched.

Another important issue that the focus group noted was the sound effects. Depending on whether a note was pressed correctly or incorrectly, an additional sound to the note pressed was played simultaneously. This had caused some confusion when the focus group tested the application, and many of the members had found the sound effect distracting. As per their suggestion, we deleted the ‘correct’ sound, and changed the ‘incorrect’ sound to a less distracting one.

A notable piece of feedback was that if we wanted to market our game to younger students then we would need to change the register of the notes. When young students learn music they tend to vocalize the notes, and if we use notes in an octave that is too low then we may risk injuring the students’ voices. We did not end up implementing this change because the original plan was to make additional octaves unlockable, and we did not have time to implement the multiple-octave feature, as will be discussed in Sections 5.1 and 5.2. However, it would have addressed the vocalization issue.

We note that the focus group participants were all secondary school music educators. When presenting this application to them they mistakenly assumed that the target audience was for a younger demographic. However, this has opened a gateway to a new target audience. As will be touched upon in section 4.2.4, it is possible to re-design this app in such a way as to target schools, music teachers, and students specifically.

One of the participants stressed the importance of having instrument-specific sounds according to the user's need. As such, that participant recommended that having specific 'skins' for instruments other than the piano may be very useful.

4.2 Survey Results and Discussion

To conduct the survey, the WPI Qualtrics page was used instead of Survey Monkey because of its more advanced platform for designing, capturing, analyzing and interpreting data sets. The survey received responses from 39 participants who were mainly between the ages of 18 to 22. Our data may be biased as many of the respondents were family and friends. The audience was still diverse, however - responses were received from an array of diverse countries such as USA, Singapore, Thailand, Nicaragua, Spain, UK, and more. The following sections will describe the demographics, and will analyze the results of each question by describing more in-depth what the participants thought of the specific components of the application. Refer to Appendix B for the survey questions, and Appendix C for the survey responses.

In many of these questions, the participants were prompted with five categorical options (Excellent, Good, Average, Poor, Terrible) per question. We chose to rank these options numerically on a scale from 1-5 (1 being terrible, 5 being excellent), which allowed us to calculate numerical data.

4.2.1 Demographics

We created a pre-game survey to collect demographic data in order to understand who played the game, as well as to verify whether the participant was in the range of the target audience. Although there were 39 total respondents, the data may have been skewed due to bias resulting from a lack of variation in the age of most respondents, as well as the fact that most responses were from friends and family members.

The respondents ranged between the ages of 18 to 52. The mean age was 24, while the median and the mode were 20. Eighty seven percent of the respondents were under 26, while the rest were above 45. These extremes skew the data because of the deviation between the younger and older generation when it comes to understanding technology and games.

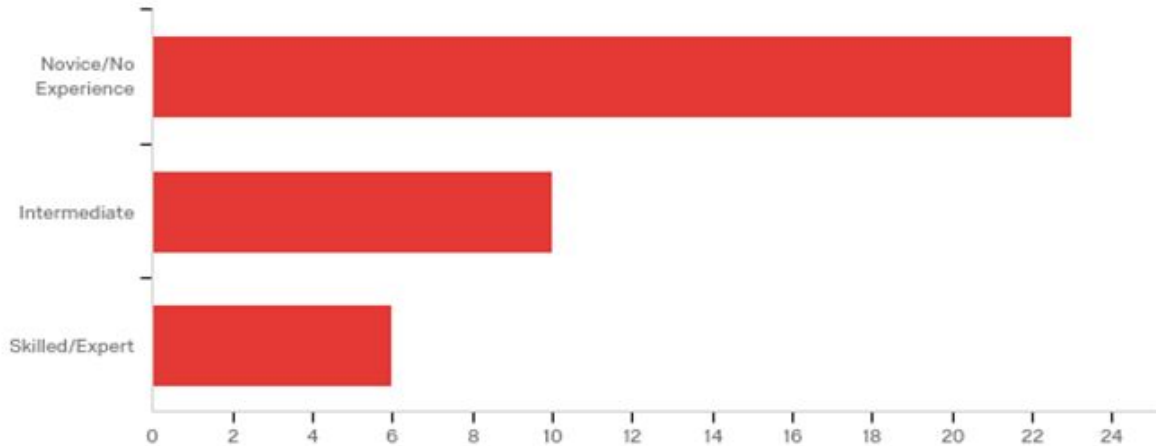


Figure 20: Rating level of musicianship

As specified in the background research, our target audience includes musicians and nonmusicians. We wanted the game to be easy to use by people who have had hardly any to no experience in music, as well as those who are very experienced. According to the results obtained on the demographics survey, there were a variety of experiences as seen on Figure 20. More than half of the people fell under the Novice/No Experience level of musicianship, while about fifteen percent listed themselves under being Skilled or an Expert at music. However, in spite of the fact that there was quite a diverse group of people with varying levels of musicianship, the degree at which they could determine a note through relative pitch averaged between sometimes and about half the time according to Figure 21. This question was important to ask before playing the game, as it helped us with further examining the effectiveness of *Name of Game* in improving one's relative pitch skills.

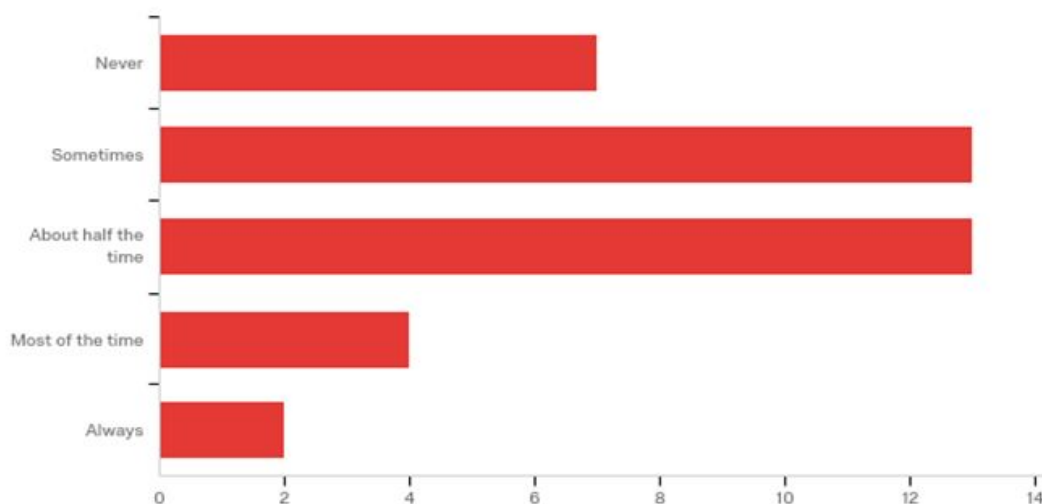


Figure 21: Rating the participant's ability at identifying a note by ear

4.2.2 Difficulty of Game

On Figure 22, the majority of the responses fell into the categories of moderately challenging and very challenging. One recurring complaint was that buying more notes made the game significantly harder. A player noted that it was “strange to feel rewarded by directly buying more difficult notes.” Another respondent stated that because the difficulty curve might be too steep, it “discourages players from purchasing the higher notes.” Additionally, our balance between rewarding correct playing and punishing incorrect playing tended to fall more heavily on the punishment side.

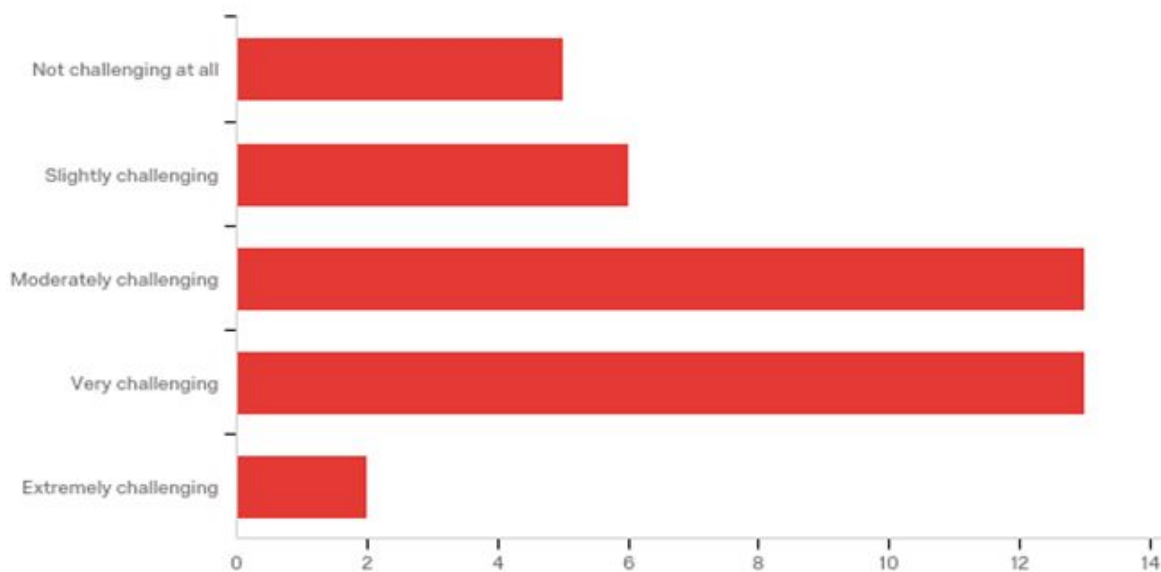


Figure 22: Rating the difficulty of the game by the challenge given

In several cases, players were losing motivation to keep playing when over challenged after buying too many notes. Those that did not fall under the hands of greed (meaning that they bought too many notes early on) indicated that the game would become less difficult with more practice, and that it kept them interested depending on the rate at which they unlocked notes. A solution to diminish these challenges can be done by improving the scoring system. Although *Name of Game* gives each player the freedom to progress at their own pace, the scoring system should ‘force’ them to unlock notes in a certain order. One player suggested to use the “streak as the unlocking mechanism.” In this case, the game could even be more goal driven as players would need to get a certain streak before being able to progress further.

Another reason as to why the difficulty varied between moderately and very challenging was because some people found it difficult to remember the tone that had played. This was seen through complaints on the ‘replay note’ button, as well as the number of attempts to get a note right. A respondent expressed that it seemed as if he was “getting punished for every mistake [he/she] made” from the “deduction for [the] wrong note, and the deduction for using the ‘Replay Note.’” A couple of players also shared their views on forgetting what the note sounded like after their first attempt. Those were the players who struggled the most especially with the increasing costs of the Replay Note. A solution is to either make that button free or inexpensive to use.

4.2.3 Overall Enjoyment

The average value for the overall enjoyment curved closer to good (4) than average (3) at a value of 3.62. As seen on Figure 23, more than half of the respondents thought their enjoyment was much higher than average: 49% chose good (4), while 10% chose excellent (5). None of the results were terrible (1). Seeing as games are meant to be entertaining, getting results in the “Good” section is preferable to people saying that our game is not enjoyable.

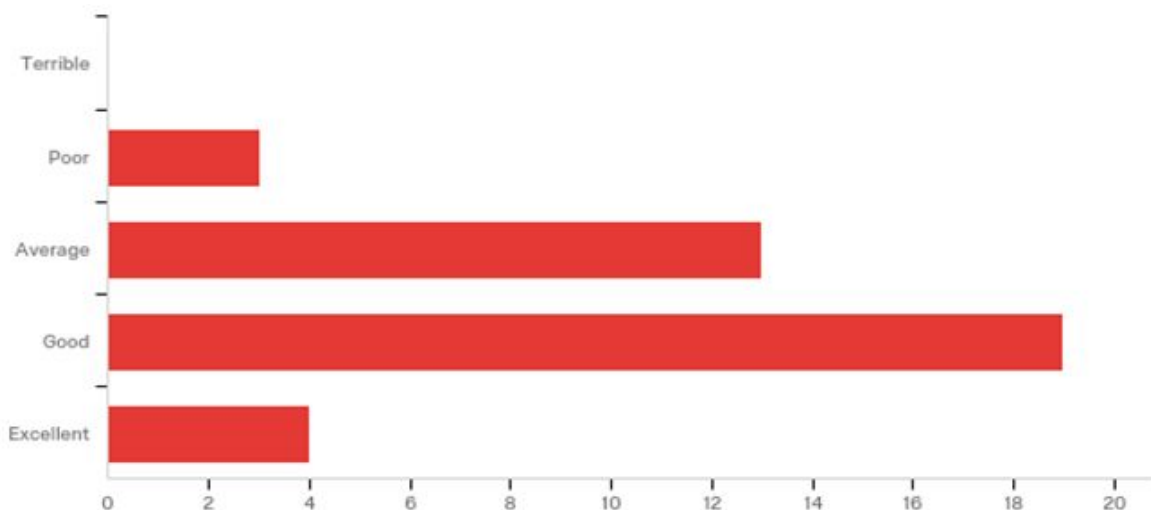


Figure 23: Rating the Overall Enjoyment of the game play

The increased difficulty after purchasing any item appalled numerous players from continuing the game further. Another factor that diminished a player's overall enjoyment had to do with the fact that overtime it became very repetitive. A player expressed their concerns as it became monotone after a while with the notes playing at random. They suggested to make the game more goal oriented or to include patterns (sequences) or melodies, as only random notes makes the game relatively boring.

Overall, the players who were able to figure out how to play the game properly enjoyed it the most. Even though a couple of people declared that the beginning of the application wasn't that intuitive, after getting "the hang of it, it was easy to use." One player stated how "although it was challenging, it was fun to test [his/her] own abilities." Even a non-musician who described themselves as "not musically attracted" and who would rather play other types of games rather than *Name of Game* was able to still enjoy it. Once they started, "it was fun to continue."

4.2.4 Overall Game Concept/Idea

The responses for the overall game concept, as seen on Figure 24, were superb, because not only did the results average to 4.18, but also none of the survey participants selected any choice under average. Several that elaborated their choices stated that the "concept [was] great in order to practice and learn." One individual who has "no prior experience" stated that the concept of the game is "a fun way to practice hearing the difference between notes and learning a little bit about music." This comment and many others proved that the concept of the preliminary design was effective among people of all types of musical experiences and abilities. It also helped to confirm part of the selected target audience.

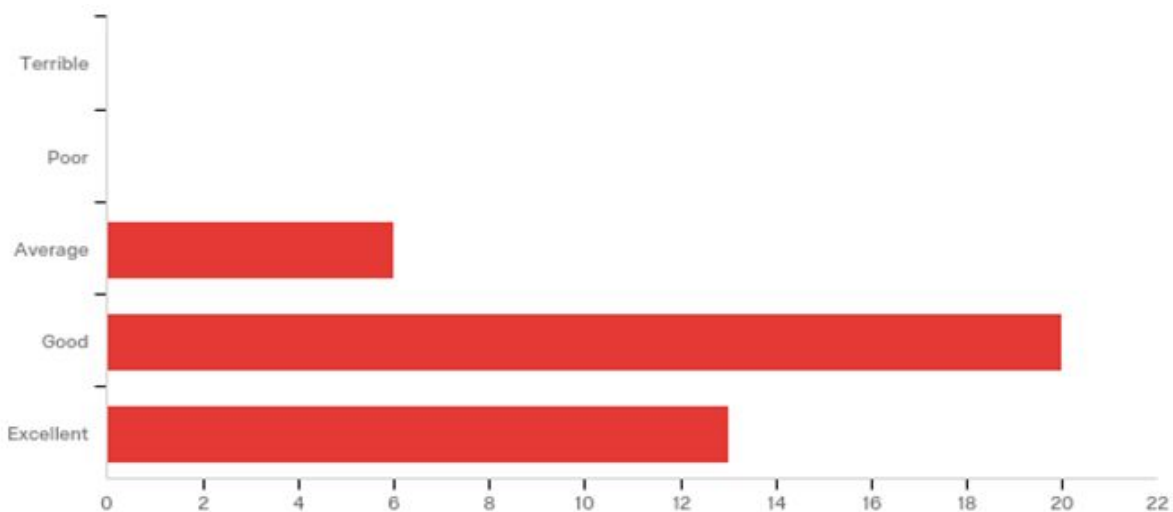


Figure 24: Rating the Overall Game Concept or idea of the game

Although no one who took the survey knew of our intended target age group, an interesting remark by one of the participants was to make the game target schools, music teachers, and kids. This was a subject that was also touched by the music experts interviewed in the focus group. They all veered into the idea that the game was specialized more for students and kids, rather than our intended audience between the ages of 18 to 40.

4.2.5 User Interface

When asked to rate the UI the majority of the participants answered with ‘Good’ in all categories. However, when asked to provide additional comments the reviews were mixed. One participant noted that “the colors work well together, although there is a lot of blue. It makes the orange-yellow pop” while another participant noted that the UI could “look a little more visually appealing”, suggesting the use of a “brighter color to entice the user”. Similarly, the UI was described as both “too cluttered” and “easy to follow.”

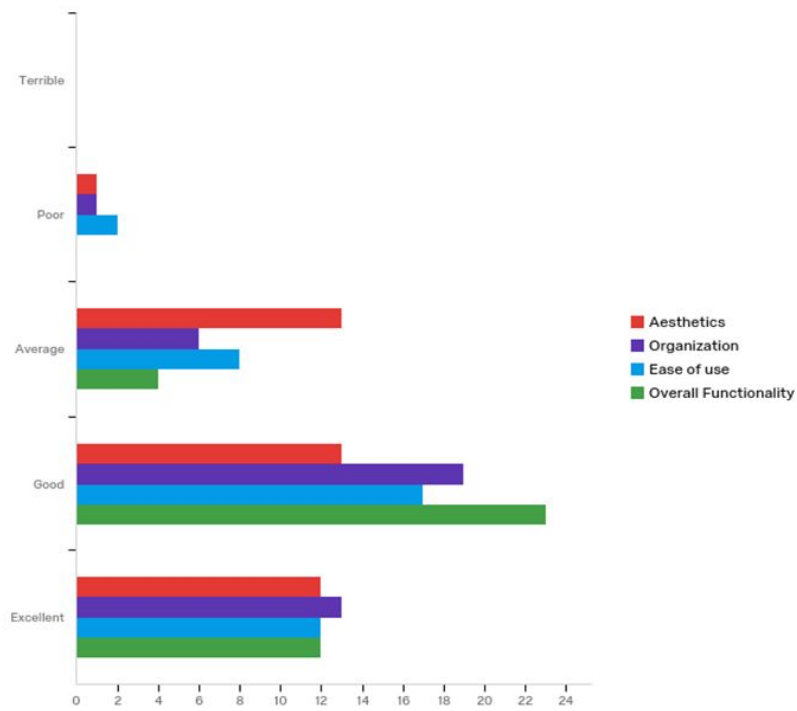


Figure 25: Rating the User Interface by the following categories: Aesthetics, Organization, Ease of use, and Overall Functionality

There were also recurring complaints. For example, using the mouse alone was difficult, and many of the participants would prefer to have the notes assigned to the keyboard instead. This was, in fact, implemented, but never explained to the participants. A suggested solution would be to place the specified keyboard key on the piano keys, instead of the corresponding note, such as ‘a’ on the keyboard represents note C on the piano, ‘s’ represents note D, ‘d’ represents note E, etc.

Another issue was the organization of the buttons on the game screen. One person stated “I didn’t realize I was spending points for the replay button for a while”. A good remedy to this

problem would be a more comprehensive tutorial. An alternate solution would be to add a larger red warning sign when the button is clicked.

In general, people felt that the messages left something to be desired. We got a response that said “I would improve the message indicating that you can unlock more keys, it was not clear to me that you could continue unlocking them”. Another response read, “In the tutorial mode you may want to prompt to show people how to buy new notes”, although the need for a more comprehensive tutorial is explored in Section 5.2.

4.2.6 Effectiveness of App in improving Relative Pitch

The mean response value for this question was 3.41, which means on average people believed the game did a good job in assisting with ear training. Most of the answers were on Very effective.

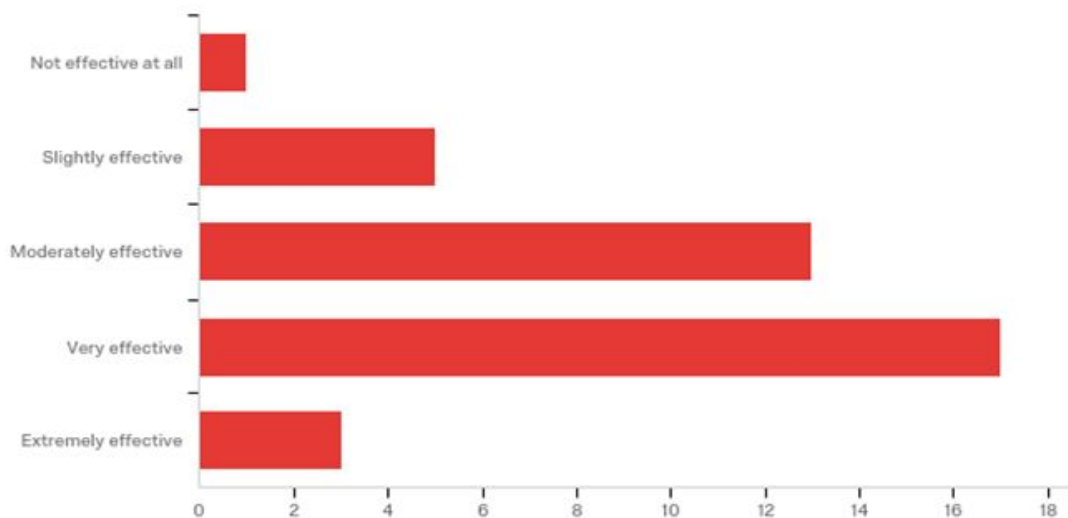


Figure 26: Rating the effectiveness of the game in improving relative pitch

In the comments, many players said that with repetition and time this could really help their relative pitch skills. But those who progressed much faster than others (i.e. bought more notes) had more trouble in the long run. One person said, “I managed to pick up the notes easily when unlocking the first 5-6 notes, but when unlocking more notes the game became increasingly challenging”. It seems that the game would do a better job of teaching the notes if each additional note cost even more, but that would also make the game less enjoyable because the thrill of unlocking something would happen less often. Another person said, “In just a short amount of time playing I could see drastic improvement in my ability to recognize the notes”. The rate of learning with this game is high in the beginning, making it thrilling once people understand the rules. Yet another person said, “By exposing my brain to repetitive keys it trained

myself to associate certain sounds with letters and numbers. I believe this is an effective way to teach a person any skill.” People who are playing the game believe they are learning valuable music skills.

4.2.7 Multiplayer Mode

This section was very poorly written in the survey, because it was a mode we had in mind, but we had not fully developed the idea of it yet. Since it was hard to convey the full idea, we tried to keep it simple. Even though forty-four percent of the participants replied with ‘Maybe’s’, more than ninety percent of those participants thought it would be a good idea to implement competition. They were only unsure of the way we tried to explain it.

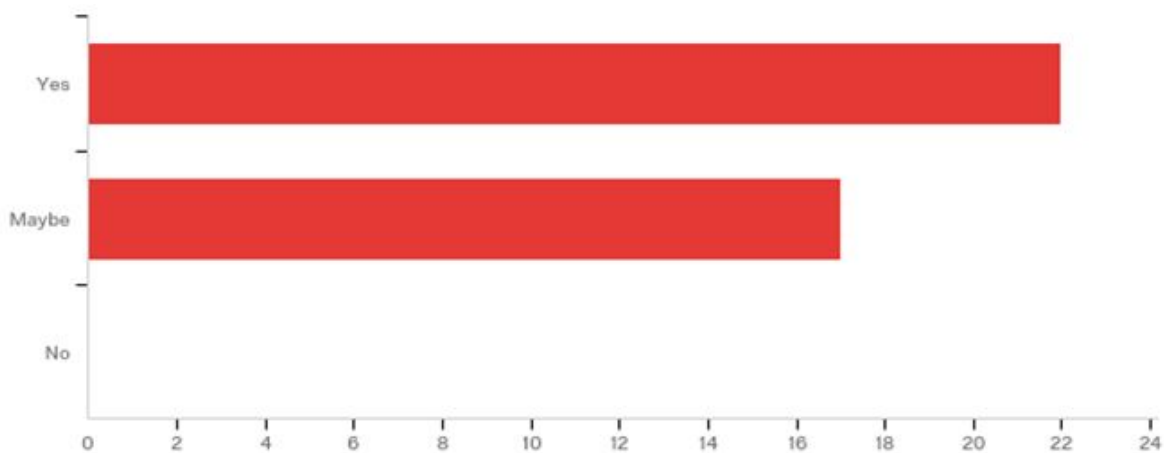


Figure 27: Responses on whether a multiplayer mode should be implemented

Various comments even extended on the research done on competitive multiplayer modes as seen on section 2.3.5 *Player Modes*. Not only did they think that it “has the capacity to turn into a fun and dynamic play-to-win-game,” but also they believed the “competition is a great motivator.” One player even supported multiplayer mode because they believed it would be beneficial by improving their enjoyment of the game through competition. They said, “I can see this actually helping me identify notes if I played it more or [by] competing with another person”. It seemed others also thought that competition would be helpful. One of the participants, throughout the survey, kept mentioning how playing with her sister was a “bonding experience.” She mentioned that when competing against her sister, the game was not only fun, but it made her concentrate more. She believes that this game “would work even better in a multiplayer context.” Another person stated that they could imagine “games across the net, [in] real time [,] challenging friends to identify a series of notes.”

In general, people thought multiplayer mode should fall into one of several categories. One idea was that multiplayer mode should be a simple real-time battle to see who can match the most notes the fastest. Another theme was the concept of the leaderboard: you're not directly facing any other people, but you can compare yourself to others to see how you're doing in comparison. Finally, there's the live battle form of multiplayer, where actions that one player performs in the game has a direct impact on the other person's gameplay - achieving a combo allows you to remove one of the other players' notes, for example. A modification to the battle concept is a "Turn based game where you can choose different action that all require different challenges, and the effectiveness of the action depends on your performance in the challenge."

5 CONCLUSION

5.1 Hypothesis Revisited

Our hypothesis asked whether the mechanism of incremental games, which encourages addictive behavior, could be useful to informally explore the aspect of relative pitch. The results of the survey suggest that with better incentives, our assumption could be true because our game was successful in captivating the user's attention. Some of the respondents even implied how addicting the game was while playing. However, the game failed to hold the user's attention in the long term as the difficulty curve was very steep. Besides the score increasing much quicker after unlocking notes, there were no other incentives to keep a player from quitting.

While it is hard to collect data about whether this game actually improved a user's musical ability over time, many users self-reported that the game made them better at relative pitch [4.2.6].

5.2 Future Development

Unfortunately, two months were too brief a time period to develop a complete application. Based on survey reviews and unrealized ideas, this section proposes further development in the future.

- Browser and App (Phone/Tablet) development
 - The current designed prototype is a Java Application which can run on Windows and macOS operating systems. However, to make the game more accessible to a wider population, we need to put *Name of Game* on the internet and on the app stores for Android and iOS. This has been the original goal of this project, and has been suggested by the focus group and the survey group.
- More on Ear Training

- Reflected in section 3.3.3 *Ear Training*, further implementation of playing multiple notes simultaneously (as chords) as well as playing notes in sequence were considered in future updates of the game. From our background research as well as responses from the survey and focus group, we came to the conclusion that teaching people to recognize chords and notes in sequence are essential in helping improve the user's relative pitch skills.
- Multiplayer Mode
 - The initial concept of the game was actually planned out to be a multiplayer game. However, because of the discovery of the incremental game model, and the fact that we did not have time to set up a proper client and server, we instead chose the singleplayer route. The structure of the program code still permits for a multiplayer mode, which may be implemented in the future.
- Better Incentives
 - A recurring response from the survey participants and the focus group were to increase incentives when buying notes, as they did not see the point of progressing if it only made it more challenging. For further development the game can be made more goal oriented, such as Jetpack Joyrider. This way, the player would not only be rewarded when accomplishing certain goals, but would also have a sense of achievement even if the game gets harder.
- Expandable Tabs
 - By making *Name of Game* an application that can run on devices such as phones and tablets, we will certainly need to condense the information displayed on the screen to make it less cluttered. A survey participant recommended to make expandable tabs in order to hold information that isn't imperative when playing the main part of the game. The use of these expandable tabs would be explained in the tutorial.
- Improved Tutorials
 - The tutorial section could be better developed. Right now the tutorials are short and only explains key game mechanics. A better version would be an interactive in-game tutorial where players are forced to execute certain actions. This makes sure that the player is unable to progress until they have mastered specific tasks and demonstrated their ability to complete the basic gameplay element [3.4.2]. The tutorial could also be expanded to cover more game concepts, and will only be applicable to players who are new to the game so that it does not show a lengthy explanation of the game everytime it starts.
- Educational Software Route
 - After receiving feedback from our focus group, we have learned of the integration of music and technology that goes on in classrooms. It is possible to redesign

Name of Game into a classroom friendly application which teachers can use to teach students of intervals and relative pitch.

- Customizable Interface and Sounds:
 - Though the current interface of the game is based on a piano, we want to add the ability to change this interface to other instruments. Both the visual interface and audio will be changed to the instrument accordingly.
- More Octaves:
 - Currently, the playable notes in the game range from C3 - E4, which makes the game relatively easy to finish for the more advanced players. We could prolong the duration of the game by increasing the possible number of notes that could be played. However, this means that the size of the piano interface will need to increase horizontally, or we would need to implement some kind of side-ways scrolling mechanism so that all of the notes can be reached.

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APPENDIX A: Focus Group Consent and Questionnaire

Approved by WPI IRB (7/17/17 to 7/16/18)

IRB File #18-0001

Consent Form

You are invited to take part in a focus group to help design a music application for musicians and nonmusicians.

Introduction: You are being asked to participate in a research study. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation.

What the study is about: To evaluate a software application for its educational value in teaching relative pitch to both musicians and nonmusicians.

What you will be asked to do: We will introduce preliminary design of our software application, after which we will ask you a series of questions to evaluate it. The interview is expected to last between 15 to 30 minutes.

Risk and Benefits: There are no anticipated risks to you if you participate in this study, beyond those encountered in everyday life. There are no benefits to participating in this study.

Taking part is voluntary: Taking part in this study is completely voluntary. If you choose to be in the study, you can withdraw at any time without consequences of any kind. Participants can choose to skip any questions. Participating in this study does not mean that you are giving up any of your legal rights.

Your answers will be confidential: Any report of this research that is made to the public will not include your name or any other individual information by which you could be identified. The records of this study will be kept private. Recordings will be destroyed after transcription, and records will be kept in an electronic database. Your data will be anonymous which means that your name will not be collected or linked to the data. The data collected in this study will be used to further improve the design of our music application.

If you have questions or want a copy or summary of the study results: Contact us at the email address above. You will be given a copy of this form to keep for your records. If you have any questions about whether you have been treated in an illegal or unethical way, contact the IRB Chair (Professor Kent Rissmiller, Tel. 508-831-5019, Email: kjr@wpi.edu) and the University Compliance Officer (Jon Bartelson, Tel. 508-831-5725, Email: jonb@wpi.edu).

Statement of Consent: By proceeding with the study, I confirm that I have read the above information, and have received answers to any questions. I affirm that I am 18 years of age or older, and I consent to take part in this research study.

Contact: If you have any questions regarding the focus group, please contact us at manzobuddies@wpi.edu

_____ Date: _____

Study Participant Signature

_____ Study Participant Name (Please print)

_____ Date: _____

Signature of Person who explained this study

Focus Group Interview Questions

1. How important is understanding relative pitch in learning music?
2. How proficient are you in determining a note with relative pitch?
3. How did you acquire relative pitch? Did you have any particular method to it?
4. How would you teach relative pitch to others? Specifically those who don't know about it.
5. Do you feel like the curriculum you use to teach does enough to reinforce/introduce students to the notion of relative pitch?
6. We have explained to you our idea for using technology to teach relative pitch. Do you think this will be effective? Why or why not?
7. Is there anything you like or dislike about our application in particular?
8. What recommendations do you have that could improve our application?

Sample Email

Dear (Name of Focus Group Participant),

We are a team of students from Worcester Polytechnic Institute (WPI), and for our Interactive Qualifying Project (IQP) we are designing a music application with a main goal: To teach the concept of relative pitch to both musicians and nonmusicians in an enjoyable and educative manner.

Currently we have a preliminary design in the form of a minimum viable product that contains only the most important components of the game. It features the main mechanics of the game as well as the user interface. We would like you to test and familiarize yourself with our

application, whereas a focus group interview will follow. In the interview, we would like you to evaluate the potential educational value this application may have in achieving the aforementioned goal described.

We are currently gathering a focus group and our advisor, V.J. Manzo, has referred us to you. If you would like to participate, please get back to us as soon as possible at manzobuddies@wpi.edu. In the email, a consent form has been attached, as well as the set of questions you will be asked in the interview. Feel free to answer any question if you feel like you have the answers to them.

Sincerely,

Bhon Bunnag, Yeggi Lee, Alex Taglieri and Yil Verdeja

APPENDIX B: Survey Consent and Questionnaire

Approved by WPI IRB (7/17/17 to 7/16/18)

IRB File #18-0001

Introduction and Consent Form

We are a team of students from Worcester Polytechnic Institute (WPI), and for our Interactive Qualifying Project (IQP) we are designing a music application to teach the concept of relative pitch to both musicians and nonmusicians. We will have you test out our software application, after which we will ask you a series of questions to evaluate it. The game is expected take between 5-15 minutes, and the survey questionnaire is expected to last 10 minutes.

Any report of this research that is made to the public will not include your name or any other individual information by which you could be identified. The records of this study will be kept private in a secure electronic database. The data will be retained for 3 years before being deleted.

By proceeding with the survey, I not only consent to taking part of this research study, I also confirm that I have read the above information, and have received answers to all questions and concerns.

By answering the questions and providing your email at the end, you are eligible to enter a raffle to win a \$40 gift card. Your feedback can increase the chances of winning the raffle. We will not disclose any of the information you provided by which your identity may be compromised.

Survey Questions

Q1 What is your age?

Q2 *A musician is someone who composes, conducts, and/or performs music, such as an instrumentalist or singer.*

Rate your level of Musicianship

- Novice/No Experience (1)
- Intermediate (2)
- Skilled/Expert (3)

Q3 Relative pitch is the ability of a person to identify or recreate a given musical note by comparing it to a reference note, and identifying the interval between those two notes.

Rate the degree which you are able to determine a note through relative pitch?

- Never (1)
- Sometimes (2)
- About half the time (3)
- Most of the time (4)
- Always (5)

Test the following game attached. Give yourself about 10 minutes to play around with it.

Q4 Rate the difficulty of the game

- Not challenging at all (1)
- Slightly challenging (2)
- Moderately challenging (3)
- Very challenging (4)
- Extremely challenging (5)

Q5 Please Elaborate

Q6 Rate your overall enjoyment

- Terrible (1)
- Poor (2)
- Average (3)
- Good (4)
- Excellent (5)

Q7 Please Elaborate

Q8 Rate the overall game concept (idea)

- Terrible (1)
- Poor (2)
- Average (3)
- Good (4)
- Excellent (5)

Q9 Please Elaborate

Q10 Rate the User Interface by the following categories

	Terrible (1)	Poor (2)	Average (3)	Good (4)	Excellent (5)
Aesthetics (1)					
Organization (2)					
Ease of use (3)					
Overall Functionality (4)					

Q11 Please Elaborate

Q12 Relative pitch is the ability of a person to identify or recreate a given musical note by comparing it to a reference note, and identifying the interval between those two notes. Rate the effectiveness of this app in improving your relative pitch skills over time

- Not effective at all (1)
- Slightly effective (2)
- Moderately effective (3)
- Very effective (4)
- Extremely effective (5)

Q13 Please Elaborate

Q14 In Multiplayer Mode, players compete against each other to see who can better fulfill the tasks. Depending on how well you do, you can attack your opponents to try and win. Do you see potential for the game to have a multiplayer aspect?

- Yes (1)
- Maybe (2)
- No (4)

Q15 Please Elaborate

Q16 If you have any additional comments or questions, please feel free to write them here:

Q17 To enter in a raffle for a \$40 gift card, please enter your email below:

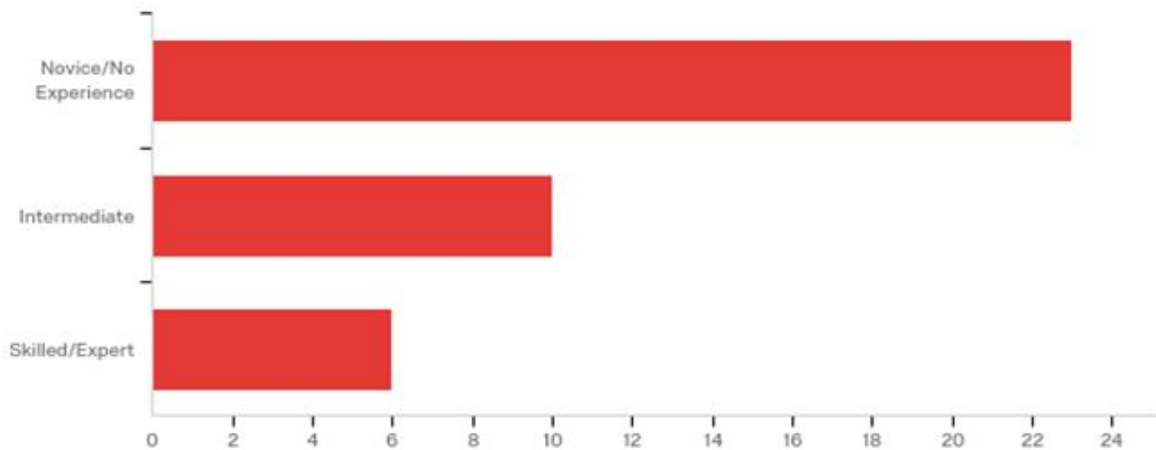
APPENDIX C: Survey Responses

Pre-Game Survey

Q1 What is your age?

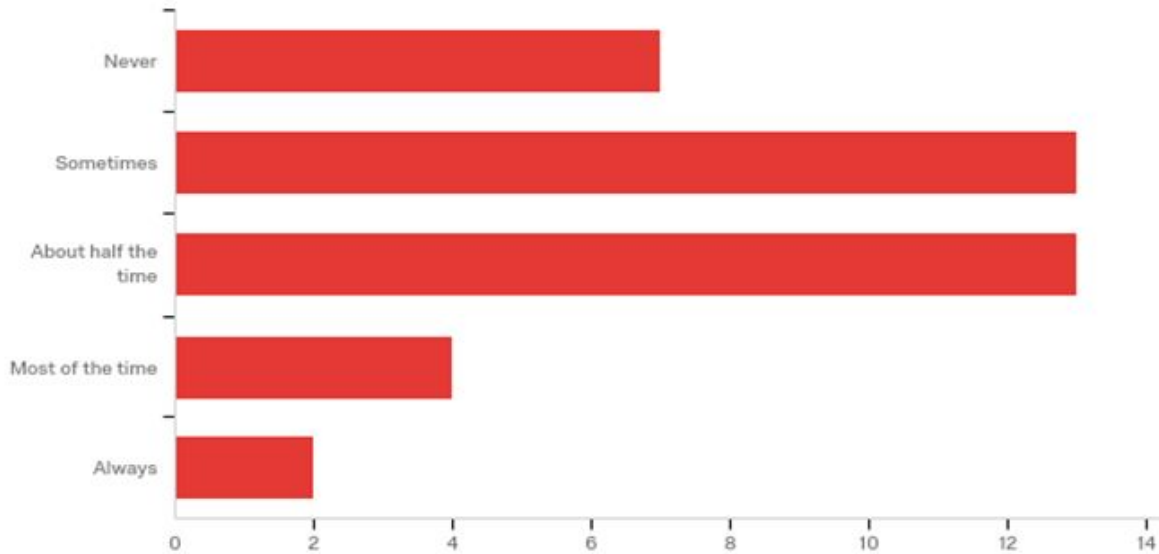
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	What is your age?	18.00	52.00	24.03	10.04	100.79	39

Q2 A musician is someone who composes, conducts, and/or performs music, such as an instrumentalist or singer. Rate your level of Musicianship



#	Answer	%	Count
1	Novice/No Experience	58.97%	23
2	Intermediate	25.64%	10
3	Skilled/Expert	15.38%	6
	Total	100%	39

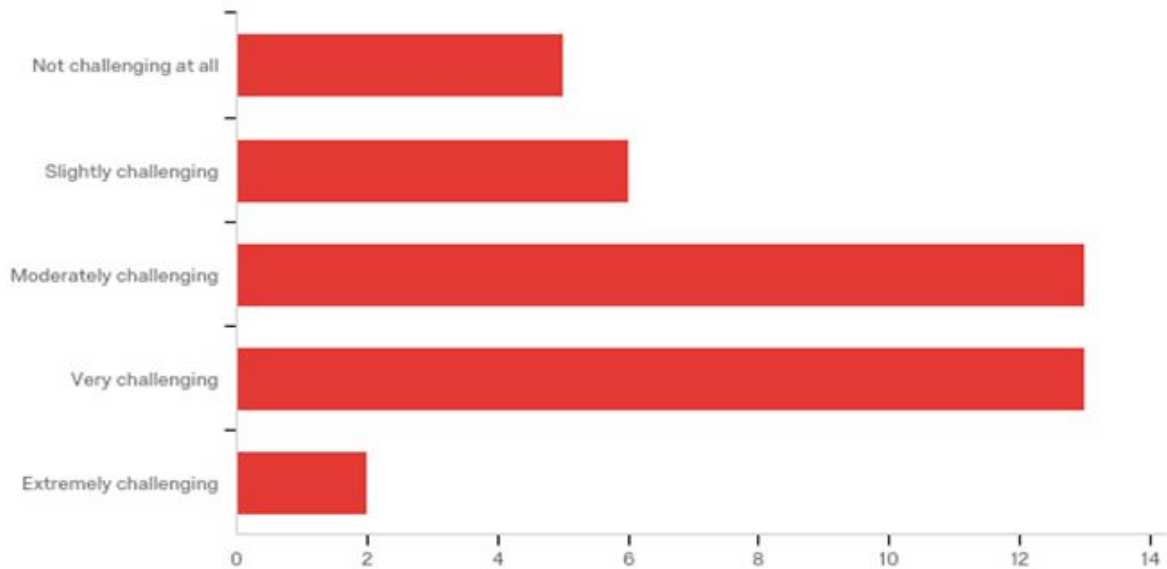
Q3 Relative pitch is the ability of a person to identify or recreate a given musical note by comparing it to a reference note, and identifying the interval between those two notes. Rate the degree which you are able to determine a note through relative pitch?



#	Answer	%	Count
1	Never	17.95%	7
2	Sometimes	33.33%	13
3	About half the time	33.33%	13
4	Most of the time	10.26%	4
5	Always	5.13%	2
	Total	100%	39

Post-Game Survey

Q4 Rate the difficulty of the game



#	Answer	%	Count
1	Not challenging at all	12.82%	5
2	Slightly challenging	15.38%	6
3	Moderately challenging	33.33%	13
4	Very challenging	33.33%	13
5	Extremely challenging	5.13%	2
	Total	100%	39

Q5 Please Elaborate

Please Elaborate

(1) Although there were instructions at the beginning, they were not very clear, so I was completely lost at the beginning! Had to do trial and error, punching buttons around to empirically figure it out for a few minutes. I think having a "demo" of how it works, as well as a "practice round", could be useful for the user. (2) For example, the first note was "lost" and there was no way to replay it. So we had to punch whichever note, and get it wrong on purpose, so we could catch up again and play! I think the replay option should always be available. Because otherwise you have to punch wrongly on purpose, just to hear it again... and it's just a matter of memory. Literally not remembering what sound it was, not necessarily not knowing which one it is once you hear it. (Don't know if this makes sense) (3) For someone who is unfamiliar with musical language, it might be useful to have the whole set of notes played out for you, so you can learn to recognise them by ear, and identify which note is which. Especially as you start unlocking notes, you have no idea how they sound, unless given a "preview" option of its sound. Or an option to hear the whole scale. I had to play the whole range in my head each time to figure out which note it was, because I'm not familiar with what they're called! Don't know if this makes sense? Perhaps having a demo of the range of notes could be useful as well for the user. (4) It could also be useful if each time you have enough points to unlock a note, there is a reminder (there was one the first time at the beginning, but none after that). I played until I had like 300 points and forgot I could buy more! As in, what could be the incentive for the user to buy/unlock more notes anyways? If it'll get complicated? For example, a suggestion could be that instead of "buying" points, it could be that after you reach a certain number of points, you're automatically "upgraded" to a new level, with another note unlocked, and you can progress level by level instead (note by note). That way, the user has the incentive to be climbing up levels, and the feeling of accomplishment to be progressing through the game. (I forgot I had points, and bought like 5 of them together, and then it was no fun!)

I managed to pick up the notes easily when unlocking the first 5-6 notes, but when unlocking more notes the game became increasingly challenging

It was hard to follow the note because they were being played too rapidly after the note that the player plays, however, over time you do get used to the rapidness of the game and you learn to think more quickly. It is drastically harder when you buy more than one note at a time.

hard to remember the sounds of the keys.

Simple is good

It was fine at first and then later EVERYTHING WENT DOWNHILL (after like 4 notes).
TT

The game is quite simple; however, as you buy new notes, it get slightly challenging to recognize one note from the other.

as someone in the latter half of their music degree, most of the ear training present here I've already worked on quite extensively. More challenging for someone at my level would be longer strings of intervals (in dictation class we call these interval strings, at the highest level it involves dictating 12 - tone rows) or notes played simultaneously (particularly in farther apart octaves)

It was cool. I used to play piano so it was familiar, might be harder for people who haven't touched a piano

It is challenging and kind of addictive to try to get it right.

The more notes you add the tougher it gets to count in your head the notes in between

I am not very good at this type of game

The mechanics of the game are fairly simple and the premise is good. The difficulty is from the game itself. The early part of the game is very easy to determine the correct note, as the number of notes increases the difficulty also increases

I think that the difficult parts were from a design flaw that you can't get back the key if you forget it, and it's easy to forget your note while you're buying stuff

i have perfect pitch

I don't have very good pitch recognition by heart... if that makes sense. Like I can listen to two notes and hear whether the same, but I don't naturally know what a D sounds like.

It was difficult, but in a good way. The game got more and more challenging at a good rate the more notes you bought, keeping you interested.

After unlocking all the notes some of the notes were challenging to recognize.

Easy enough once I got the hang of it, flats kept messing me up, the tutorial pop up for the store confused me for a bit because I couldn't buy the replay note and the note I had to play had since left my memory while I figured out the store situation

Definitely got more challenging with more notes but it was generally easy to find the notes if I was concentrating hard enough.

I don't know much about music and recognizing notes, but as I played I was able to become more accurate. Adding more notes definitely made it more challenging, and I don't think I could have gone much beyond where I was (up to B3)

While I have no musical talent, by unlocking each key one at a time, it doesn't end up being too hard.

At least in my case, where I have a most untrained ear, this posed a challenging yet fun activity. I believe that for those who are interested in beginning to train their ear in a fun way, this is it.

As the number of notes increase the amount of challenging it gets increases quite a bit

Because I don't really have a good ear for music and tunes ,the game is very challenging at the onset, even if it only shows do, re, mi as an option. I could of course train my ear t become better and then over time the game may become less challenging and more interesting.

To someone with absolutely zero musical inclination, it was hard to keep track of all the different nuanced sounds and pick the correct one.

I have never excelled with music, and actually earned an unsatisfactory grade for music class in kindergarten. This game was difficult however with more practice became less difficult. Additionally when I first opened the application the way to play the game was not intuitive.

I don't have any musical training, so it was hard to match the pitch to which key on the piano was played

The time between the correct note you play and the next note is too short, which makes it hard to focus your attention on the next note. If any sort of indication that the next note is about to be played was there, it would make it easier.

My relative pitch isn't that good, and as a pianist, I tend to follow the habit of trying consecutive notes until I get the right one (which deducts most of my points).

Was too easy to unlock all notes

Did not get any wrong

Personal opinion as a music nubskrub: I don't think using 'Replay Note' should reduce your score. Every time I get a note wrong, I don't even remember what the original note sounded like. Seems like I'm getting punished twice for every mistake I make (deduction for wrong note and then deduction for using Replay Note).

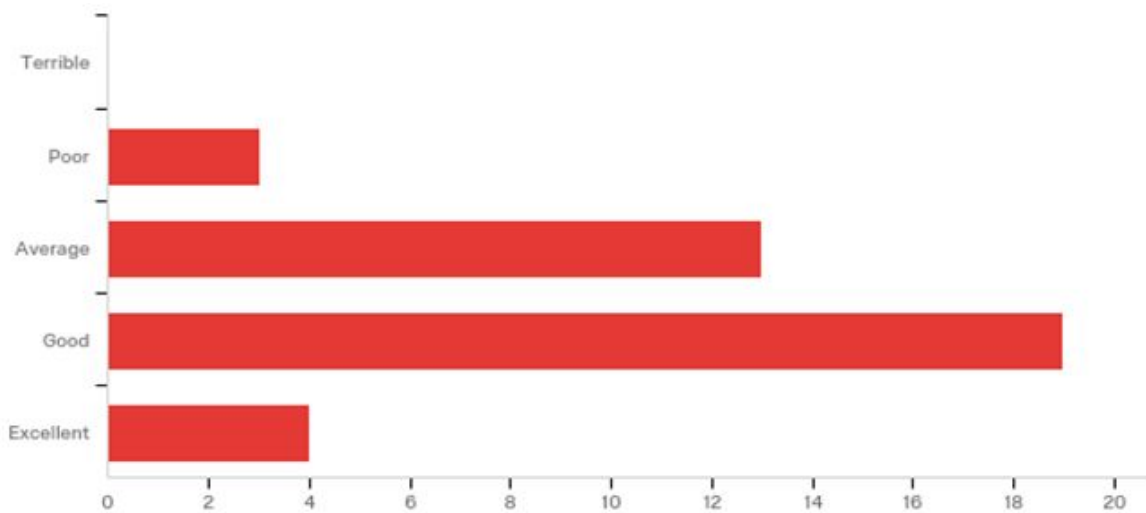
defo interesting concept

After I started to add all the black keys, I got really confused. C# sounded like C to me until they were played back to back

I am not too familiar with musical notes so it was rather hard at first but as I played I did get better. Buying new notes made it almost easier depending on which note you bought. Ones that were higher up were much easier to recognize from the rest of them.

I made a few mistakes when there were leaps from natural notes to sharps and flats.

Q6 Rate your overall enjoyment



#	Answer	%	Count
1	Terrible	0.00%	0
2	Poor	7.69%	3
3	Average	33.33%	13
4	Good	48.72%	19
5	Excellent	10.26%	4
	Total	100%	39

Q7 Please Elaborate

Please Elaborate

Had a bit of trouble figuring it out, but it's a very good idea! Would only really add the incentive part of unlocking levels instead of buying notes, to make it more engaging for the user.

I'm not musically attracted therefore I would enjoy playing other style games than this one, but still enjoyed it and once I started it was fun to continue.

This is a great way to learn a game however, it becomes monotone after a certain amount of time. You need to make it more interactive, maybe where they teach you how to play a song and what keys to use so that its more fulfilling than just being able to guess the note after its played. For me its easier to learn when its more goal oriented and when the goal is something as thrilling as learning a song and not just random notes (which is still very important, dont get me wrong).

i wanted to keep going

At first I didn't understand that you could continue unlocking keys, so it started to get repetitive. After I figured it out, it became more interesting, until I reached the point where I was unable to distinguish the notes very well, because there were too many of them.

It was good until I started sucking too much at it. :(Break down the levels more of section them off into batches because after 4-5 notes it becomes harddddddd.

I used to do this game with a real piano when I was learning how to recognize notes. That is why I find it slightly nostalgic and I enjoy it more. Also, I love the sounds that the game gives you when you make mistakes, and the graphics are pretty neat as well, so it is easy to enjoy.

I've played and worked with a lot of ear training tools in the past, and I have to say I like a lot of things about this. The interface looks nice and is satisfying to interact with. The idea of 'buying' new notes is an interesting one, although I'm not sure if I'm totally sold on it. I might be totally off the mark here, but the system seems pulled out of 'flyer' games like learn to fly and burrito bison, in which you can buy yourself upgrades to increase your characters effectiveness and move further in the game. In some ways the system in place here feels almost like the opposite, and it's strange to feel rewarded by directly buying more difficult notes. Like I mentioned in the challenge section, more variety would also benefit here, as far as an early build goes for an ear training device, I do have to say it feels very solid

The challenge is good and I like the fail sounds.

It pushes me to be very accurate with my hearing

Quite fun

I enjoy testing my ability to determine notes based on relative pitch. It also helps me develop my ear for pitch

It's a cute idea but it's been done before and better, such as with teoria. I like the fact that you can buy notes, but I think that just figuring out the next note is sort of random and not the best practice or the most enjoyable way of practicing. Look at teoria.com, and honestly they're pretty perfect and if you want to make an app that's excellent (in my opinion) do what teoria's doing with a twist that makes your version different/unique. Perhaps enter in a test rather than cost for unlocking new materials, I don't know.

everything was very obvious, there should be varying levels like series of separate pitches or simultaneously like a chord

At first it was pretty fun because I was getting used to it and getting better, but after playing for a little while, I sort of lost the motivation to unlock new notes, since nothing special really happened. Also, maybe because I'm not musically gifted, I found that unlocked new notes made it more difficult to recognize the notes I used to know, so I didn't feel very motivated to keep playing.

It was fun to see how good (or bad) your relative pitch is. I liked that there was a notion of progression, both with the streak counter and with the unlocking of new keys.

I enjoyed the game and enjoyed adding the notes one by one.

played it with my sister, she yelled at me a lot and it was a bonding experience as I learned how inferior I am to her in every respect

Game was very fun

It definitely interesting, and I did feel that I was getting better at it, which is good. However, I think the difficulty curve might be a bit too steep, and discourage players from purchasing the higher notes.

I liked that the points you could earn would increase as you bought more keys, although it would've been good to convey that before buying a key.

It was fun!

I feel like the incentive to play this game is to get better pitch. So built in incentive is unnecessary, however so much as artwork and progression go, there can be some changes made. the whole screen feels too cluttered. Perhaps a main menu that access all the things should be considered. Also I feel that rather than have note progression be already set with notes at certain prices. Prices of new notes should be determined via the order they are bought. ie: the first note costs 5 and all subsequent notes are $5 \cdot x/2$ where x is the number placement the note was unlocked at, first, second, third, etc.

This game looks great when you are keen to improve your musical skills. because that is not really an objective for me, I am not that motivated.

I actually had fun having to discern what sound is what based on very slight differences and remembering their position on the keyboard.

I felt that I was learning what sound each key makes and that was enjoyable because learning new things is pleasurable.

Nice UI Fun

I like that you can unlock and buy new notes.

Although it was challenging, it was fun to test my own abilities.

The game didn't let me know what each key sounded like, just random ones and some of those weren't even unlocked

Nothing left to do after unlocking all notes

Got repetitive after a few minutes

Not a big fan of music-related stuff so I didn't enjoy it all that much.

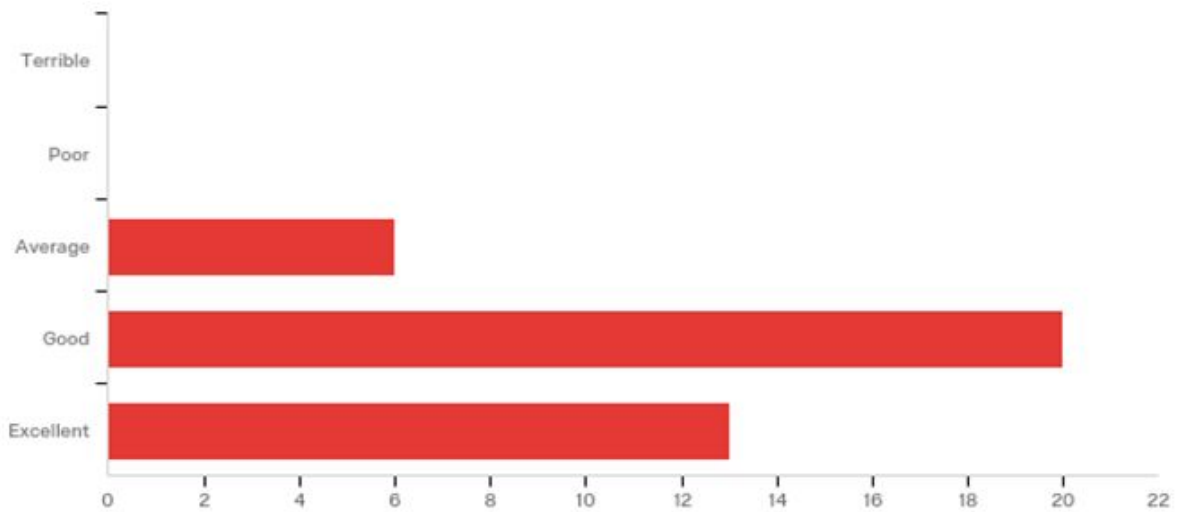
pretty enjoyable

I got really bored

It's an interesting concept that more musical people could do a lot with but it wasn't my type of game. The rewards for getting notes correct/ the penalty for getting a note wrong didn't feel very important. I think high score tracking would help. Also a way to skip the tutorial after the first time would be nice.

It's good in the sense that it helps you become aware of the pitch difference, so its a good educational tool to learning by ear.

Q8 Rate the overall game concept (idea)



#	Answer	%	Count
1	Terrible	0.00%	0
2	Poor	0.00%	0
3	Average	15.38%	6
4	Good	51.28%	20
5	Excellent	33.33%	13
	Total	100%	39

Q9 Please Elaborate

Please Elaborate

I think it's a great concept!

I felt like this kind of game was helping me recognize some notes the more I played it so I think the concept is great in order to practice and learn.

Great concept, may just need a bit of work to be more entertaining.

great concept. The longer I played, the more I got familiarized with the sounds

I like the idea - kind of like Simon, right? It gets repetitive as it is, I would like to see how it works with multi-player mode. Also, maybe do the key unlocking dynamic, once a certain point level is reached, maybe random or maybe in a preset pattern? Extend the keyboard after a certain point level? Or perhaps use the "streak" as an unlocking mechanism, rather than overall points, like in Simon.

Good concept, maybe give it some kind of background plot of a character on a mission to catch 'em all (the notes) to increase investment in the game.

This is the kind of skill that takes a bit of time to build. Therefore, I believe it is a good concept that is meant to practice this specific skill.

I really like the idea of ear training tools that use gamification to keep things interesting, and there are a lot of cool ideas in here that I feel could be very strong with more work. I don't find the current progression system very satisfying, but it definitely has legs. I would say it's the best looking ear training tool I've used, and would love to see where you go with this.

The concept is good and the kind of simple challenge that would entice me to keep playing if it wasn't midnight

I think it's a great idea that can be developed into a free app for people wanting to get better in their music hearing abilities, and with it will gather enough users that will make it worth to sell ads later on. I imagine games across the net, real time or challenging friends to identify a series of notes. The options are immense! Great idea!!

Interesting but need a bit of work on details

I like the idea of developing pitch and note determination from a game instead of using an instrument which requires a lot more effort and time to work on, especially when tuning an instrument

It's been done before, so see how other people have done it better and learn from them. There's a lot of potential for relative pitch training that other apps have capitalized on, but this one in its current state does not

would be helpful for people who want to develop perfect pitch

I think if I was a musician, I may find it helpful.

It is a fun way to practice hearing the difference between notes and learning a little bit about music, even having no prior experience.

I think for someone that is trying to improve their pitch and learn solfege this is a great software.

I can see this actually helping me identify notes if I played it more or competing with another person i.e. my sister

Great practice for ear training.

Definitely a good concept. As mentioned before, I think the difficulty curve is a bit steep, and I'm not sure what the motivation is to purchase the higher notes, other than getting more points to purchase more notes. Maybe the progression should be automatic instead of voluntary

I can see it being pretty useful. Not sure if I would play it for longer than a few minutes though.

I like the idea behind the game, the concept by which it has been elaborated, the graphics are super cool and the instructions are very good

Definitely fulfills its purpose and is a good way to train the ear when waiting for the bus or something along those lines.

The idea is pretty good, but again you need to know who you are targeting to. this may be a great game for young kids, endorsed by the parents, who could learn the basics of notes and tunes and play around it. It could also be used at schools in order to teach music in a more fun way.

It's a very interesting, yet simple idea that works as a tool to refine your musical hearing.

If I played this game for 10,000 hours I would be incredible at identify keys. This game provides a mode for musical learning

I would have liked to try multi-note mode or familiar melodies or multiplayer. In general, the game was well constructed and I appreciated the effort put into the development

I think the concept is interesting. I would play this game to train my ears for sure, there is a good educational value to it.

The concept was good, testing relative pitch - but right now it is just for the purpose of "testing relative pitch", there is not much "gameplay" or anything. It could be useful for research purposes, but still far off the idea an actual game.

Great concept to test hearing and relative pitch

Original idea but a bit too repetitive

If I downloaded this, I'd probably play it for 5-10 minutes, get bored, and never touch it again. Then again music doesn't really interest me so who knows. Also a bit curious how the other game modes will turn out.

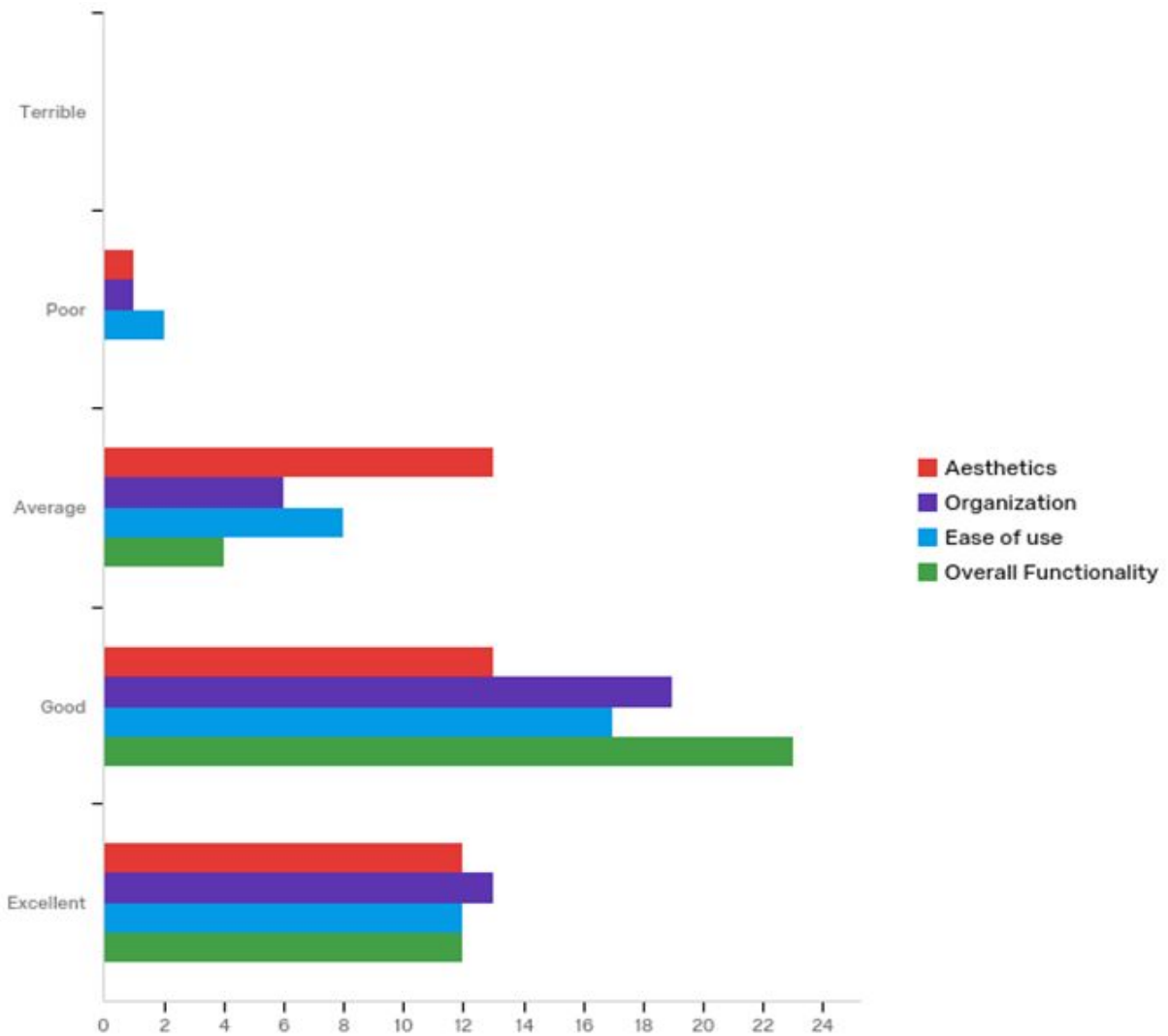
bretty good

It's a good game for those who want to improve their listening skills

I think with further development and elaboration it could be a very addicting game trying to beat your latest high score or competing with people. I think it could also work well on a mobile platform.

I think it has potential to be a fun game, however, what i realized was that there are no consequences to making mistakes apart from losing your streak. So I guess it loses the suspense and excitement of it.

Q10 Rate the User Interface by the following categories



#	Question	Terrible		Poor		Average		Good		Excellent	
1	Aesthetics	0.00%	0	25.00%	1	41.94%	13	18.06%	13	24.49%	12
2	Organization	0.00%	0	25.00%	1	19.35%	6	26.39%	19	26.53%	13
3	Ease of use	0.00%	0	50.00%	2	25.81%	8	23.61%	17	24.49%	12
4	Overall Functionality	0.00%	0	0.00%	0	12.90%	4	31.94%	23	24.49%	12
	Total	Total	0	Total	4	Total	31	Total	72	Total	49

Q11 Please Elaborate

Please Elaborate

Had to punch a bunch of buttons around to figure it out intuitively, but if there's a demo option, to take you through one round of the game or to practice, it could be really useful!

At the beginning of the game I did not know whether it had started or not and I felt sometimes the notes did not repeat after I missed. When I missed I was more focused on the sound of the note I clicked rather than remembering the original note.

Could look a little more visually appealing, maybe brighter color tone to entice the user. Very easy to use and follow along which is great. In the tutorial mode you may want a prompt to show people how to buy new notes.

the # keys were hard to read. took me 2 tries to figure out how to unlock keys. Was never able to unlock sequence of sounds, so it got boring after a while. Needs more instruction on what to do when you hit several wrong keys, you get the wrong sound and don't have points to replay, so I didn't know what to do...

It would be nice to see all the functions, and of course, some polishing in the looks would help, but the interface is clean and easy, and reasonably intuitive. I would improve the message indicating that you can unlock more keys, it was not clear to me that you could continue unlocking them. I understand that this is a test, but it may be a good idea to make the unlocking progressively more difficult to achieve. It was too easy to advance from one level to the next.

Nice graphics, maybe code the game to include tips to help if the player struggles too much.

Aesthetics are great! My only critique, for both organization and ease of use, is that I feel like everything is close together. It is just merely my personal preference.

Already touched on this... the UI is great. Might be nice to have different options for displaying pitches (without a keyboard for example) but it's also fine the way it is.

The aesthetics can be improved but they are good enough. With ease of use, I found it easy but I sometimes missed the black keys using my cursor.

I compare the interface with what's out there in the apps world now. This one looks very basic but excellent distribution of items on the screen. The font on the notes could be

graphics instead of characters. It needs, in my view, a more attractive graphic design to be marketable.

Want to see how it goes next

The colors work well together, although there is a lot of blue. It makes the orange-yellow pop. Overall the interface is solid, nothing special though.

So it's a cute interface, but there are a lot of things that seem meaningless, why do the costs and number of points scale so much so quickly? It's sort of confusing. Particularly because at first I was trying to collect 10 points and after 10 minutes I was collecting over a thousand per correct guess. So my input is a few things. First, I'd say limit the sessions and give them a goal. Like have little missions like in jetpack joyride that you try to complete in your game. Give three goals and a session is finished when you've completed all the missions. Then keep track of those goals being met and after a goal has been completed a certain number of times, make it harder (first get 10 notes in a row correct, then after that's been done 3 times get 15 notes in a row correct). And when these goals are met, get a mini prize, and when the session is done, you unlock new prizes/notes and get even more money to buy new game modes. My next main thing is that instead of fitting all the game modes and note buying into one page, make a shop with unlockable and then buyable prizes so you can better scale the game and also clean up the interface. Having everything in the same place makes it cramped and you'll be able to do more with less if you can move the shop. Same with other game modes, you split up the multiplayer and single player but within single player you should be able to choose your play mode. Last, if I haven't mentioned this, you need to include a reference to the key for people when they need it. It's not to test how long you can remember the note when you're buying things in the store.

everything was good

It's very comprehensive

Looks very clean and is easy/intuitive to use.

The user interface can look a little more modern and use more colors, but the overall software is easy to use and navigate.

cute aesthetics, cartoony thing is really working. I didn't realize I was spending points for the replay note button for a while so organization in the sense of providing a tutorial left some to be desired, wish there was another way to select notes other than mouse

A little hard to figure out how to play at first or which note it was trying to get me to play when it would play two notes in a row.

Looks great and easy to use. I'm not sure how you buy the last items in the store. It might be easier to control if you used the keyboard instead of the mouse to play notes, since we are already accustomed to hitting keys on the keyboard without looking.

Overall, it works well and I haven't been confused or anything like that. Aesthetics could be improved with little things, like animations of pressing keys. Ease of use could be improved by letting the player know they can use their keyboard as controls.

I had no problem understanding the layout or playing the game. And as posted before, graphics are cool

Too cluttered, too much going on. As a player and a modern player thrown straight into the game from the get go, the limited space and the amount of things cluttered into the space is overwhelming and prompts me to not want to explore it. Aesthetics and font choice are good but need more color or at least maybe a more interesting theme. It's a piano, so maybe use wooden textures? If it were up to me I would set the right menu and the left shop into an expandable tab or accessible via a pause menu so the focus of the player is only on the piano.

As it is still in early phase, the aesthetics are pretty simple. In a today's world, it is expected to be much more sophisticated. Otherwise, people will easily get demotivated.

The UI isn't particularly fancy but it works perfectly and it's easy to understand from the get-go.

Nice interface, but was a little unintuitive at first. Once I got the hang of it it was easy to use.

I would also play the note once it is bought, so I knew how it sounds.

GUI is good, although it is very normal by today's standards. It is very easy to use, but for the functionality: there is a note 'C4' where it is staccato.

Interface is nice and simple to understand.

It was a bit difficult to figure out which note I was supposed to press at first

Looks clean, simple. Plz include option to turn off tutorials.

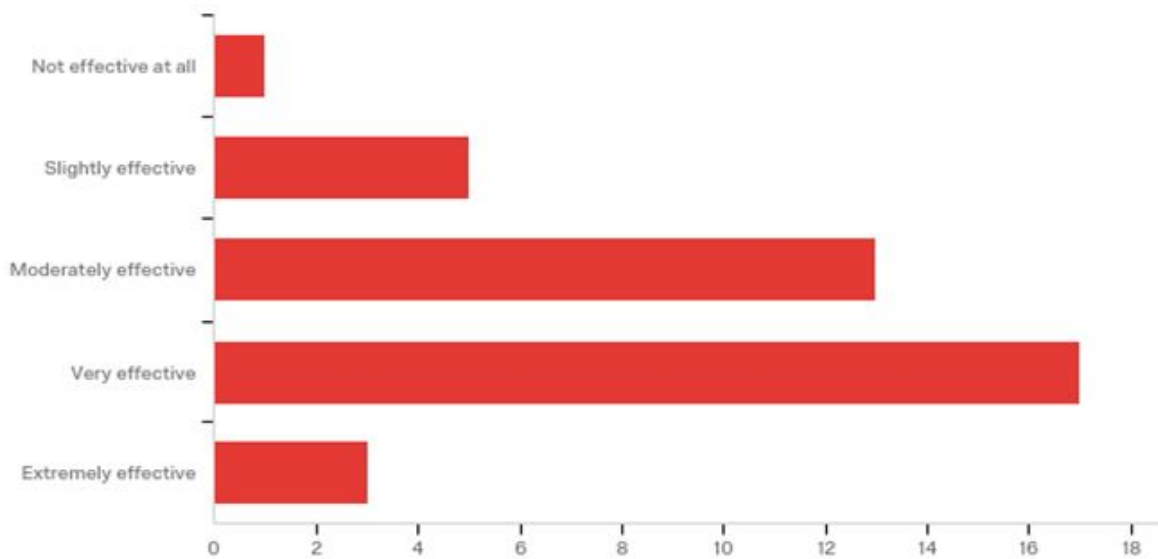
pretty streamlined

eh. the survey is pretty elaborate itself.

The actual game screen looked nice but the popup dialog boxes didn't fit the theme of the game. It was fairly easy to use but it took a little bit to figure out what was going on. It is a very basic game right now but with additional development I can see it being pretty fun. A way to load in save games would also be very useful.

At first i was a tiny little bit confused as to how to start the game, but once you get the hang of it it's pretty straightforward with what you have to do.

Q12 Relative pitch is the ability of a person to identify or recreate a given musical note by comparing it to a reference note, and identifying the interval between those two notes. Rate the effectiveness of this app in improving your relative pitch skills over time



#	Answer	%	Count
1	Not effective at all	2.56%	1
2	Slightly effective	12.82%	5
3	Moderately effective	33.33%	13
4	Very effective	43.59%	17
5	Extremely effective	7.69%	3

Total	100%	39
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Q13 Please Elaborate

Please Elaborate

Answered this two questions earlier.

with repetition I started to recognize more and more which key was the right one in relation to the sound before last.

In my case, repeated use helped to be more proficient in identifying relative pitch, and did so very quickly, until I reached a point where there were too many keys and I could not distinguish them well.

Good, but my greed for unlocking more notes diminished my ability to learn a few notes thoroughly and only hurt me in the long run.

I think if I spend more time playing it would be more effective.

Having worked with apps almost exactly like this I can say that they work VERY well for relative pitch. Most of my relative pitch skills come from various ear training apps (I think the one I used was called ear-for-life but I can't remember at the moment)

It would be good if I continue to practice.

After a while it was becoming easier to choose the next note

Need more practices to be more effective.

Anecdotally, I improved my relative pitch skills over about 20 minutes. I think that if I continue with this game my relative pitch will continue to improve.

Relative pitch encompasses a lot more than this app suggests tests or trains. Because it's not for only one note, it's for detecting chord quality in different inversions, recreating that chord, hearing intervals in parallel and one after the other, hearing the root of a progression, and much more. You're not really testing any of that. Just getting one note after the other can work a bit on relative pitch and intervals, but like, look at teoria again and actually use it. That's a phenomenal and free resource and if you're just gonna make something that does what teoria does but worse, then don't do it. Your only hope is to capitalize on the fact that this is a game. But there's still a lot of functionality that teoria has that you need if you want to successfully train people's relative pitch (chords and longer sequences). So first, add functionality, and then if you want to train people the key thing I don't think you have is you need an effective way of measuring progress. The point of training is you started at this point and you've progressed to this point. You don't go to the gym and just lift the same weight for a random amount of time and then leave and expect to have good progress. You need to work yourself in different ways. Train speed and accuracy separately until you can do more faster and better. That's how you train. So your game needs to scale with skill level instead of money.

i already have perfect pitch

I'm not sure if I've actually improved, since the more notes we added, the more confused I got

In one sitting, one can get a little frustrated after a while and maybe not improve all that much. I do think that playing it more over time has really good potential to improve relative pitch skills, but I will have to try it out.

this app basically acts like a practice on an actual piano and I think it's pretty effective.

I was really bad at first, but really improved at identifying them. I kind of regret buying new notes since they made it so much harder, I think you might need to provide more incentive to spend points, since spending them in the shop increases difficulty and who spends money to make life harder for themselves?

If this was played enough times, I definitely think it would help with a person's relative pitch.

It seemed like I was improving, but as I moved forwards it became more and more difficult much faster than I could improve.

It made me associate more with the location of the keys rather than the keys themselves.

I think that with practice, this could be quite helpful

Rather than having the incorrect note and the wrong sound clip played when a wrong note is played just the monkey chirp notifying the player of a wrong note should be played. This prevents the player from associating the wrong note with the expected note, then the correct note should be played again to remind the player of what to look for. Another thing to note here is that due to the nature of the keyboard and the visuals of the game the individual playing the game is most likely to associate the pitch to the image or location of the pitch on a piano rather than its actual note name.

If I were to play the game a few times, I would definitely get better at it. Loved the challenge! (although most of my answers were wrong though...again, some practice may be needed)

This is a fun way to improve one's ability to recognize different sounds.

By exposing my brain to repetitive keys it trained myself to associate certain sounds with letters and numbers. I believe this is an effective way to teach a person any skill.

It is tough with no formal music training to train my ear. With practice, I could slowly gain this skill with this game

it's good for ear training

It could be good, making memory through repetitive action.

I can already identify pitches, i just didn't know which button to press

Very helpful app to help practice identifying relative pitch.

Not sure

No clue if I'm any better than when I started.

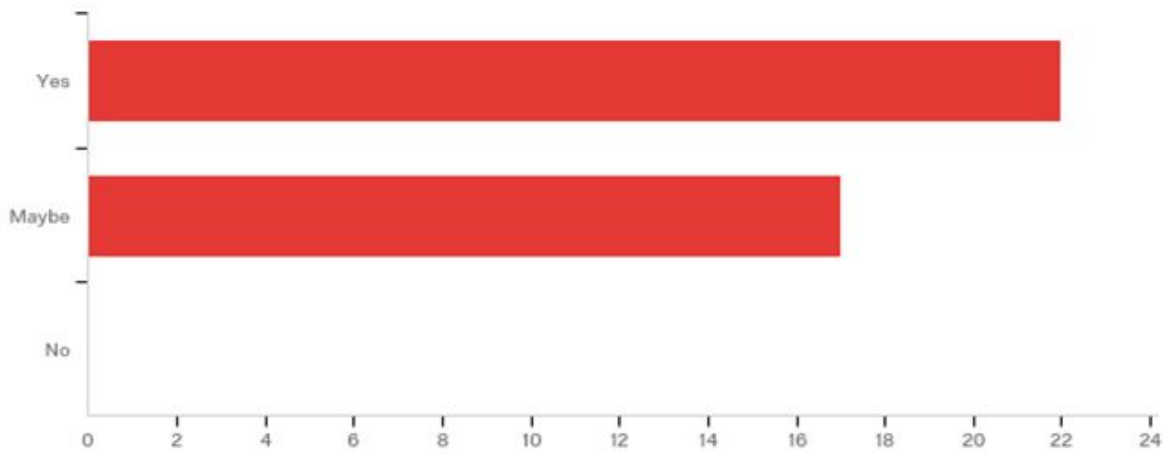
it's fun and would probably develop your pitch skills

i just said moderately because I don't know... never really used it over time

In just a short amount of time playing I could see drastic improvement in my ability to recognize the notes.

I think over time if you use this app, I think it will prove to be quite useful in developing your skills when it comes to identifying relative pitch.

Q14 In Multiplayer Mode, players compete against each other to see who can better fulfill the tasks. Depending on how well you do, you can attack your opponents to try and win. Do you see potential for the game to have a multiplayer aspect?



#	Answer	%	Count
1	Yes	56.41%	22
2	Maybe	43.59%	17
4	No	0.00%	0
	Total	100%	39

Q15 Please Elaborate

Please Elaborate

Absolutely

Seems hard to play this multiplayer but if worked on any game can be done for more than 1 player.

Yes i see potential, it needs to be more thrilling than just notes though, you need it to be a song or something that makes it more enjoyable for the user to win.

i see the potential. would that work so if one player fails the other starts? uhm, how would the other starts if the first one is really good?

I wonder how "attack" would work, remove the other player's keys? Or add them, to make it more difficult? Or perhaps use timing?

I like being able to attack my opponents :) How would I be able to attack them though?

I wonder how exactly would you be able to play multiplayer because you have to take into consideration introducing the level system or handicap mode to make things fair. It has potential, but I would have to think about the concept you guys will be coming with to see whether it will work or not.

i LOVE this idea. particularly if it had an element of strategy, perhaps a turn based game where you can choose different actions that all require different challenges, and the effectiveness of the action depends on your performance in the challenge (i'm imagining like an ear training multiplayer paper mario, if you're familiar) I would have a lot of fun with this.

Sounds fun

Yes, but I didn't try it. Same like playing "Words with Friends"

Online or insitu. You can challenge your opponent with single or multiple notes. The farther the note from the previous one, the more you win... or risk.

Depend on how you create, we may be able to have player complement each other and average the score. Random pick so we can team players against another pair in a tournaments like ranking.

Yes, I think being able to battle with other people will be beneficial because having a timed aspect to relative pitch cements how well a person can recall there knowledge eventually leading to the information becoming reflex.

I think it would be hard to make it fair and ensure that the intervals have relatively the same difficulty, but if the tasks are fun and equally challenging it's worth a try.

competition is always fun

Anything with competition against another person tends to hold my attention for longer

I think there could be a way to do it, but it may have to add new features, beyond just the repeating the note. I like the idea of some sort of competition with interaction between the players.

I would assume most people would use this game to practice music and I'm not sure if people if users would want to use it as an entertainment with others.

my sister played with me and it was fun and made me concentrate more, so I think this would work even better in a multiplayer context

Sounds like fun! Competition is a great motivator.

I'm not sure if it's necessary, and I also don't know if I understand fully. The two players would take turns at one computer? That might slow it down too much. I would say focus on the difficulty curve and encouraging or forcing the player to progress.

I don't know what you have planned but I would be like who can press the correct key first? I don't know but I could see something working.

Sounds like a fantastic idea!! I would absolutely play this in multiplayer mode

It would most likely have to be something akin to Tap Tap. Would need more details to make a good judgement.

There is always an extra excitement when you can show off your music skills. for some players, that would be a bonus.

I feel it works best as a simple musical learning tool, but it definitely has the capacity to turn into a fun and dynamic play-to-win game.

Competition fuels humans. More people will want to play the game. Would be good as a smartphone game.

it would be a fun challenge to play with others

Was not really sure what that means, but if that would add the competition aspect to the game, I would like it more

Multiplayer always makes the game more competitive and thrilling.

Could be fun like tetris

Not sure

????? What does attacking your opponents even mean? Anyway, in its current state, I think this game is better suited for single player mode.

for musicians

like a competition

If rather than using points to buy new notes the points were compared to determine the winner or used to buy attacks/powerups it would be pretty fun to compete with people. I think a real time system would work best where people are racing to get the most points.

Sounds fun, but how do you play in multiplayer though? Do you create accounts and it becomes like an internet game where you can challenge different users? I'm curious as to how you'll make this possible, but I do like the idea of challenging someone!

Q16 If you have any additional comments or questions, please feel free to write them here:

If you have any additional comments or questions, please feel free to write...

Super super well done!! Look forward to seeing/using the next version when it's done! :D

Good Job on the game!

Great job with the organization of the game, it works flawlessly!

great start!. I think a sequence of sounds would be more fun and help with distinguishing and recognizing the size of the intervals

I think it is a great effort, good job. Have you tried it on a tablet? I would think ti would work well, since you could use the touchscreen for the keys

It is a great game! Got me hooked for 20 minutes before I remembered that I had to continue the survey. It would be pretty good to also include a timer mode to see how much you can do, say, in a minute or two? The game can get a bit monotonous after a while, but I am sure that such a creative group can be able to make it more interesting!

Really cool stuff! I'm excited to see where this goes

I would have liked to know that I couldn't do it on my phone before I started the survey. I also would have liked to know that I should have saved the game, but I closed it already.

Making it easy to open is really important. I liked the fail noises. Made me laugh. Maybe it would be interesting to be able to "buy" a hint with points.

As a team, you have created and developed an amazing idea for a class. The potential to keep developing it is vast and worth keep exploring it. Great job to each of you!!

There's probably a lot more to say, but yea the main thing I guess is to spend a LOT more time in design before moving to implementation. I hope I'm not misreading this or making light of anybody's hard work, but it feels like you skipped the design process and went straight into building. First: Research courses on how to improve relative pitch, what are the relevant aspects of relative pitch and what are the goals of people trying to develop their relative pitch. Second: What resources already exist? WHAT'S WRONG WITH THEM? Third: How do you make something unique that addresses the problems or builds off of other apps. And that's just to start refining your idea. So my recommendation is to go back to the drawing board and capitalize on the fact that you're making a game and use that to offer something that scales better to develop relative pitch from an undeveloped level to a master level. hmu if you need me to elaborate any of my answers, and good luck

very well made :D <3

t one point, the repeat note button wasn't working for me

The game was very fun and pretty challenging (in a good way) overall. It kept me interested and wanting to improve, and it looks great, too. After playing for a few minutes, however, the game seems to have crashed on me. I don't know if that is specific to my computer perhaps, since I haven't tested it elsewhere, but I clicking the keys does not do anything now. I can still try to buy new notes and the reset button works, but it is not playing new notes and most buttons do not work.

It would be preferable to have this play in a browser or phone app; I had to update my version of Java because of this :(but doubtless you already had that in mind

I think you can remove the tutorial from showing every time you press play even though you've played before. Not too big a fan of the failure sounds, I think just visual feedback may be better. You've probably thought about this already, but what if instead of buying notes, you unlocked them based on how high your streak is? Feels like it could be a more natural progression.

Very good job, guys!

- Remember to make the app also work on mobile - Having to download java before you can play is a bit of a bommer

great job a stretch goal could involve adding the ability to select the key, which would help its functionality as an ear trainer

I think that overall the game is very well thought out. I like the tutorial in the beginning and the layout of the game. It's easy to follow and you can intuitively navigate through UI. I like that there are +1, -1 pop ups every time my score increases and decreases, which makes it easier to know if i played it wrong/right. I think that sequence mode will make the game more interesting, so i'm looking forward for the implementation. I don't really understand what the multiplier does, but overall I think the game is pretty good. Good job!

no :3

I think you should have to buy notes near each other to increase the difficulty and slowly fill out the entire keyboard. Having a keyboard that could expand would also be pretty cool.

The game stopped giving me notes after a while, and my point score showed "403..." --- Is there a limit to points? Also, I couldn't click other buttons to unlock anything else. I don't know if I was allowed to and it wasn't working, or it simply hasn't been developed yet. Another thing I feel would be interesting, would be at the end of each "round" of the game, if it could show you a list of the intervals where you made mistakes, to see where you struggle the most? I don't know I was just thinking about the idea that I couldn't remember where exactly I messed up.

APPENDIX D: User Interface Design

Icon Design

The lock icon used in the game was designed by Jerry Low¹¹ and belongs to his WHSR January Flaticon Set. The icon is licensed under free for commercial use.

The rest of the icons in the game were designed on Gravit Designer¹², which is a full featured vector design application that can be either be downloaded, or used on a browser. Not only does it closely resemble Adobe Illustrator, but it's also free to use.

Font Design

The font used in the final interface is called Bungee, designed by David Jonathan Ross. It's released under the SIL Open Font License which means that it is completely free and open source. Bungee can be downloaded from Google Fonts¹³ or David's personal website¹⁴.

¹¹ <https://www.iconfinder.com/jerrylow>

¹² <https://designer.gravit.io>

¹³ <https://fonts.google.com/specimen/Bungee>

¹⁴ <https://djr.com/bungee/>